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ABSTRACT

The results of research work undertaken by the University of Pittsburgh, and the Interuniversity Communications Council (EDUCOM), in behalf of the National Library of Medicine on the general subject of biomedical communications and information networks is summarized. The principal purpose of the project is to explore the potential of the new communications technology for the distribution of medical information to physicians in support of their clinical, research, and educational interests. The research indicated that the world of medical information is a multi-dimensional problem. Medical information varies not only as a function of the physician's speciality, education, environment, and personal interests, but also as a function of his relationships with his patients and as a function of time. (Author/MM)

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RESEARCH MEMORANDUM

Biomedical Communications Project

SUMMARY OF RESEARCH MEMORANDA

January 1969

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Prepared for the
Lister Hill National Center for Biomedical Communications
Bethesda, Maryland

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January 1969 (5)

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TABLE OF CONTENTS

	<u>Page</u>
I. INTRODUCTION	1
II. THE DOMAIN OF BIOMEDICAL COMMUNICATIONS	6
III. BACKGROUND FOR BCN SYSTEM DESIGNERS	16
LIBRARY SERVICES COMPONENT	18
SPECIALIZED INFORMATION SERVICES COMPONENT	67
SPECIALIZED EDUCATION SERVICES COMPONENT	80
AUDIO AND AUDIOVISUAL SERVICES COMPONENT	87
DATA PROCESSING AND DATA TRANSMISSION FACILITIES SUPPORT COMPONENT	92
OF GENERAL INTEREST TO ALL COMPONENTS	116
IV. INDEX TO ACCOMPANYING RESEARCH MEMORANDA	128

I. INTRODUCTION

This report summarizes the results of research work undertaken by the University of Pittsburgh, and the Inter-university Communications Council (EDUCOM), in behalf of the National Library of Medicine, on the general subject of biomedical communications and information networks. The principal purpose of the project was to explore the potential of the new communications technology for the distribution of medical information to physicians in support of their clinical, research, and educational interests.

The project, which was begun in October 1966, embraced in its investigations the total environment within which a biomedical communications and information network might someday function. Several research objectives were formulated: 1) to develop a comprehensive, basic, and detailed appreciation of the health sciences community - - its nature, location, functioning, and trends; 2) to survey the status of health sciences libraries in the United States in order to ascertain the extent to which such libraries can be integrated into a operative biomedical information network; and 3) to identify those elements of the new technology which may be applicable to the design of future biomedical information networks.

The project embarked on a comprehensive program of interviews, meetings, and conferences. Almost 200 persons were contacted during the first year. More than half were M.D.'s;

the remainder were technicians and specialists, such as engineers and librarians. Interviews were conducted with general practitioners, specialists, medical researchers, and educators. Meetings were held with NIH and PHS representatives. Visits were made to the hospitals, medical schools, and government agencies, such as the Veterans Administration and the Pure Food and Drug Administration. Conferences were arranged with medical librarians and with knowledgeable persons in the various medical professional societies and in industry. Three EDUCOM Task Forces - - one on clinical applications of the computer to medicine, one of information networks, and one on continuing education - - were briefed on the project so that they might most profitably express their views and contribute constructive criticism.

Furthermore, since most of the medical schools in the U.S. are at EDUCOM universities, their staffs were continually called upon to furnish information and guidance to the project. Throughout the research period the project staff examined pertinent biomedical literature and, with assistance from NLM, was able to remain abreast of new materials in the field.

In 1968, the National Library of Medicine created a separate division, dedicated to research and development, whose mission is the creation of a national biomedical communications and information network. During the second year, therefore, the project worked closely with the Associate Director for Research

and Development and her staff, in order to ensure that the research data assembled by the project would support NLM's on-going plans and programs. In this connection, EDUCOM supervised four sub-contracts designed in each instance to either test a basic assumption or develop an idea to the point of implementation.

The philosophy of the project has been to understand the nature of the medical information problem in all of its ramifications in order to develop the perspectives needed for planning the design of a network. Technology, while far from forgotten, was temporarily set aside while the project concentrated its attention on the question of what should be communicated on a medical information network, and for whom - - rather than how - - the network should be constructed.

Our research has taught us that the world of medical information is very difficult and complex in structure, and at times it seems limitless in scope. From the standpoint of the physician, information in medicine is clearly a multi-dimensional problem. It varies not only as a function of the physician's specialty, education, environment, and personal interests, but also as a function of his relationships with his patients and as a function of time. One researcher has dramatized the physician's dilemma by saying, "The more patients he sees, the less he can keep up; the more he keeps up, the fewer patients he sees."

In sum, it is important to observe that the idea of

automated information networks--inside or outside the medical community--is a very young concept. The project has been unable to locate examples of operating systems now in existence. There are, however, many organizations in the federal government and in the private sector that are aggressively working toward the networking of medical information. From the evidence gathered in the medical world, one can sense that momentum is building up for some form of multi-media networking. At some local and regional points plans are already in being designed to satisfy information needs specifically expressed by individual segments of the health sciences community. Diverse efforts toward interconnection will, in the years ahead, require leadership from the federal government to assist them in linking their resources together for the common good.

We wish particularly to acknowledge the support of EDUCOM's Committee on Continuing Medical Education which assisted in reviewing project plans and objectives; and particularly to the sub-committee on Health Sciences, under the chairmanship of Dr. Kelly West. To them, and to the EDUCOM community at large, the project wishes to express its grateful appreciation for their advice and guidance.

This summary document and the research memoranda which accompany it constitute EDUCOM's final report to the National Library of Medicine in connection with the research activity of the

past two years. In addition, at the request of the Project Officer, EDUCOM has also turned over its basic files of raw data to the staff of the Lister Hill National Center for Bio-medical Communications.

II. THE DOMAIN OF BIOMEDICAL COMMUNICATIONS

Broadly speaking, biomedical communications is the process by which data, information, and knowledge in the field of biomedicine are transmitted, transformed, and transferred. A loose definition of this sort will probably suffice until the health sciences community has had more experience with applied problems in the medical information world and perceives, through much more profound understanding of communication systems, how to work with them. As of 1969, the need for deeper inquiry into biomedical communications appears evident. Moreover, it is highly probable that between now and the year 2000 A.D. at least 10 and possibly 100 times more biomedical information will be discovered or created. As the size of this information base increases, the complexity of biomedical communications will grow -- but at an even faster rate than the information base.

Given this broad view of the subject, the following section briefly describes the realm of biomedical information and communications, its special characteristics, size, problems, and current status.

More than any other field in the life sciences, the field of biomedical information is viewed from a perspective which acknowledges that it deals with the domain of human experience and activity embracing the following attributes:

A. The most elementary, primitive and personal goals which men seek, i.e., relief from suffering ascribed to illness,

the maintenance and improvement of health, and the knowledge of the parts, functions, and behavior of oneself and of others;

B. a nearly universal and personal interest in the means to these goals -- an interest which sustains and extends the traditions associated with professional medical care and science; and

C. an ever-growing number of discernible medical

1. phenomena which attract attention, prompt the construction of theories, inspire research investigations, and generate information;

2. techniques of a mechanical, electrical, chemical, intellectual, economic, and organizational variety;

3. people, who, in every conceivable context, both private and public, use biomedical information not only for traditional purposes, but also in order to obtain the "results" or "outcomes" associated with that vast range and number of abstract, collectivized, and relatively impersonal goals (e.g., defense, control, and profit) which invigorate life in its modern institutional settings.

Taken together, these attributes of biomedical information can be expressed in four ways:

a. A wish for relief from that suffering believed to be due to an extraordinary and undesirable condition (or set of conditions) which afflicts men as individual living organisms and which limits their ability to act in desired and desirable ways.

b. A search for health - a state of optimum well-being, given an account of one's circumstances. The study of health values and ideals of individuals and societies indicates that at one time or another most human activities have been critically related to the "health" of the individual person or to the "public health" of a society of individuals.

c. The use of remedies, treatments, and other techniques which directly (as in clinical practice) or indirectly (as with laws and agencies pertaining to health) prevent or mitigate the effects of disease and promote or encourage the attainment of health.

d. The requirement for knowledge which, immediately or remotely, renders illness intelligible, health definable, and practices effective. At the present time -- and as a result of the rapid development of science and technology during the past one-hundred and fifty-years -- the types and quantities of information which are accepted as biomedical frequently surpass the methods available for using it, either for the realization of practical objectives or for the answering of scientific questions.

It is when many varieties of information are used in a specific context of human events, purposes, and expectations that information becomes distinctly biomedical. In America, the concept of biomedical information refers to all that is known and distinguished concerning the varieties of traumas, diseases,

and disorders; all that is known of the actions taken in dispensing and receiving preventive measures, therapies, and healing practices; and to all the findings of the empirical sciences that bear upon the structures, functions, processes, and conditions of life.

People in the health sciences share biomedical information for a variety of reasons. If investigators could clearly identify in historical, social-cultural, economic, political, or technological terms, people's reasons for sharing biomedical information, they would be in a better position to plan for the future of biomedical communications. However, this particular area of understanding is extremely subtle and elusive. While researchers have conducted quantitative studies on the use of such sources of information as libraries, journals, drug detailmen, symposia, and post-graduate education, little research has been conducted which sheds any light on the qualitative aspects of the use of information in medicine. We suspect that the information-sharing and -seeking roles of the patient, clinician, educator, and researcher differ significantly. But research has yet to reveal which specialists in health sciences share what types of biomedical information, and what motives lead them to seek and use such information.

The probable need for and use made of biomedical information among various segments of the health sciences community may be expressed in terms of the key people who use the information:

- A. The citizen-patient has at least two reasons for

being interested in medical information. In the first place, he is solicitous of his own health and seeks assistance when he believes that his health or that of his dependents is in any way threatened. He thus reflects the initial training in the culture of health-care which he has received from his family and school. Subsequently, he is likely to reflect the efforts of agents, both public and private, who purvey biomedical information to him throughout his life. These agents are as diverse as the physicians he consults, the directors of the mass media of communications which he views or hears, and his own "voice of experience" which records his history, enabling him to interpret private experiences. Second, most citizen-patients expect to contribute something to the political, social, or communal processes whereby decisions are made regarding the public aspects of health and medical practice. For example, as more public legislation affecting biomedicine is proposed and enacted at every level of government, the citizen-patient should be increasingly eager to know the positions of his elected representatives on various matters of health legislation. The citizen also has a stake in the economics of continuing health services, the research practices within the biomedical sphere, and the organizational techniques employed in the conduct of such services and investigations.

B. The practitioner-physician, dentist, nurse, and a host of paramedical personnel are primarily interested in biomedical

information in the context of practice. There is a large amount of oral communication among practitioners and between practitioners and patients, for practice is geared to taking practical action in particular cases. Practitioners are leading producers of biomedical information. Much of the information which they use and produce is not recorded, though practice is often conducted according to a general plan: history-taking, physical and laboratory examinations, treatment, and continued observation.

Many medical practices are aimed at the preservation or restoration of the health of the individual person. But not all medical practice is case-centered. The public health official generates and uses different sorts of information from those of the traditional practitioner, for his task is to observe, to moderate, and at times to define the variables of community health measures and practices. Though the public health practitioner tends to have little direct contact with patients, his role is closely linked with that of the citizen, the scientist, the traditional practitioner, the medical administrator and the expert in communication techniques.

C. The scientist and researcher is engaged in the quest for knowledge. His purpose as biophysicist, biochemist, geneticist, physiologist, or psychologist is to discern scientific laws and to generate theories that will allow him to demonstrate whether or not "X is the case." Thus the scientist in this context is not

immediately interested in his own health, as is the patient, nor is he directly concerned with the health of the members of the community, as are the citizen and the public health official. Questions of validity rather than of care, cure, or prevention are primary when information is organized from the vantage point of the basic scientist.

There are other features of biomedical science which should be kept in mind when one surveys patterns of communication among present-day theorists. Both basic and applied research is often carried out by teams of scientists. The efforts of scientists who work in applied fields are frequently linked with activities which are immediately practical in nature - e.g., the physiology of man in space is being determined in the process of sending an astronaut to the moon; physicians are learning about the dynamics of intracardiac blood pressures as patients are evaluated for heart surgery. Finally, it should be mentioned that oral communication with fellow investigators is vital to the work of the scientist. According to Winch, the application of concepts in science is influenced both, "by the phenomena to which they are applied and also by the fellow workers in participation with whom they are applied. But the two kinds of 'influence' are different. Whereas it is on the basis of his observations of the phenomena (in the course of his experiments) that he develops his concepts as he does, he is able to do this only by virtue of his participation in

an established form of activity with fellow scientists."⁽¹⁾

D. Health Science Administrators attempt to manage a variety of historical and social institutions -- professional organizations, clinical facilities, research corporations, communications networks, and government agencies through the exercise of legitimate authority in prescribed areas of jurisdiction. The administrator must be a good communicator if he is to exercise a measure of control over the performances of subordinates, not offend the public which his agency serves, and remain responsive to the directives of superiors.

The administrator's work affects large numbers of professional personnel and patients. His need for biomedical information, therefore, is self-evident. Unless he remains continually alert to new developments, and thoroughly conversant with medical trends and progress, the organizational entity for which he is responsible -- hospital, foundation, or research institute -- will function at less than full effectiveness.

E. Information and communication experts inhabit the biomedical field for a number of different reasons. Some, such as medical sociologists, study how communications in biomedicine do in fact occur. Others devise schemes which suggest how communications (especially of the mechanical-electronic type) could or should occur - e.g., systems designers and computer engineers.

(1) Winch, Peter. The Idea of a Social Science, New York: Humanities Press, 1958, p. 86.

Still others traffic directly in the day-to-day tasks of producing, handling, and processing knowledge -- librarians, publishers, documentalists, and producers of audio-visual aids. There are others who occasionally list themselves as communications experts -- e.g., medical educators exploring the use of teaching machines and an assortment of medical publicists. It may be noted that the new circuits, both social and electronic, are colorful, exciting, and newsworthy. The greatest changes in biomedical communications will occur as the new technologies prove themselves useful in the context of the goals and purposes of patients, practitioners, scientists, and medical administrators.

Thus the biomedical information area is a special domain of human affairs identified at any given time by those people, engaged in complex patterns of associations, who give meaning to the conditions and processes we have described as health and disease and to the actions which have been called treatment, prevention, and the quest for knowledge. There is little reason to believe that the central meanings or importance of the realm will change in the near future; individuals and groups will continue: to have requirements for the maintenance of health, to suffer diseases and traumas, to desire remedies, treatments, and preventive measures, and to attempt to broaden and deepen their knowledge in all these matters. It is this understanding of the current situation that indicates that the business of biomedical communication is not new and that it involves the problems of sharing and of failing to share untold volumes of

information emerging from a great number of disciplines. It has been noted that the forms of information which are communicated may be quite simple or extremely complex, concrete or abstract, primitive or highly rationalized, and intensely personal as well as highly impersonal. It has been acknowledged that numerous devices are used in communicating biomedical information. Further advances in science and technology should permit the design of new devices which may be engineered to meet nearly any specification that is suggested in the future. In regard to these latter developments, it may be expected that the basic forms of biomedical information which were distinguished earlier in this section, through which and about which communications are made, will not change. They will, however, certainly be elaborated and compounded as new communications technologies become available.

III. BACKGROUND FOR BCN SYSTEM DESIGNERS

Forming an appreciation of the basic precepts of medicine is an essential prerequisite to planning a biomedical information and communications network for the health sciences community. This chapter aims to provide that background. While much of what it presents may be familiar to the practicing medical professional, the information included here is to assist the computer specialist, the communications technician, the librarian, the information scientist, the systems designer, and others who plan supporting roles in the health sciences community or who are otherwise concerned with understanding the medical environment.

The material in this chapter is organized by the component of the Center for Biomedical Communications to which the content most directly applies. It consists mainly of summaries of the highlights of more comprehensive studies which are included as Research Memoranda with this report. The Research Memoranda themselves represent the results of collaborative effort between the EDUCOM research staff and one or more individuals in the medical world who served as consultants. The Memoranda are generally quite detailed and include supporting bibliographies and references. (In certain instances, where a particular original report was reasonably brief, the entire content has been placed in this Chapter rather than attached as an Appendix.)

Following NLM Board of Regents action in 1968, the EDUCOM research staff was directed to give priority to the development of the Specialized Education component. This direction resulted in the preparation of a unique compendium of medical school extra-mural programs found in Research Memorandum 8.

Also, it should be noted that the memoranda relating to the Data Processing and Data Transmission Component are generally applicable to the interests of all other components of the BCN because of obvious functional inter-relationships.

LIBRARY SERVICES COMPONENT

- Composed of four levels of network participation:
 1. Center for Biomedical Communications
 2. Decentralized MEDLARS Centers
 3. Regional BCN Access Centers
 4. Local BCN Terminals

- Processing functions include:
 1. Acquisition
 2. Surrogation
 3. Storage
 4. Announcement
 5. Retrieval and dissemination

- Services to be provided:
 1. Bibliographic listings
 2. Access to the literature
 3. Response to specific requests for information

(CBC Technical Development
Plan June 1968)

RM 1 *
SOME REFLECTIONS ON THE HISTORY
OF BIOMEDICAL COMMUNICATIONS

The vital question in setting up a Biomedical Communications Network is whether the user for whom it is intended will in fact use it. This report underlines the innate conservatism of the medical profession and its distrust of governmental regulation.

This report traces communication back to the time when it was all by word of mouth. When writing was developed, few could benefit since most were illiterate; in any case the records of medicine were kept secret as its practice was a secret art controlled by the priests. Furthermore, as the method of making cheap multiple copies was not invented until the 15th Century, in many cases there was only one copy of works produced earlier.

The invention of printing led to the scientific journal and to the development of the forerunner of the present-day medical library. Learned societies exchanged publications, but already in the 18th Century readers were complaining of the difficulty of keeping up. In the 19th Century the abstract journal was created; but the need for some guide to the literature had become evident before that. Albrecht von Haller, a Swiss, had begun publishing

*We have referred to the various Research Memoranda throughout this summary as RM 1, RM 2, etc. These same Research Memoranda also have the date of publication added in some references, i.e., RM-169. Thus, RM 1 is identical to RM-169.

medical bibliographies in 1747; but others were not eager to undertake the immense work involved. One of the exceptions was a Dane called Callisen, whose 33 volumes give excellent coverage of the last half of the 18th and the first third of the 19th Centuries. The first secretary of the Smithsonian Institution tried to interest the regents in 1855 to compile an extensive bibliography of science. Although he failed to persuade them, the task was taken up by the Royal Society of London, which was to publish complete coverage of the 19th Century. Only an author index was issued, and the First World War effectively stopped any further work on it.

In medicine, however, John Shaw Billings had issued a catalog of monographs in 1872 and followed it up in 1879 with Index Medicus, for current awareness, and in 1880 with the first volume of the Index Catalogue, for retrospective search.

The Index Catalogue survived until 1961, but over the years, delays in publication time led scientists to explore faster means of making the literature available. In the Second World War, a weekly listing of medical literature known as the Current List was circulated to serving physicians and first microfilm, and later photocopies of articles were supplied on request. The microfilm copy distribution service was responsive to the information needs of physicians who, during the war years, were widely scattered throughout the world. Physicians not only received copies of

articles but were also provided with a hand optical viewer. This is one of the earliest examples of network distribution of medical information to bridge the communications gap between medical research and practice. More recently computerization has made it possible for the listings of periodical articles (Index Medicus) and monographs (Current Catalog) to become more current and hence more useful.

The report then deals with the information position in agriculture, and contrasts the vast strides which have been made in this area in transmitting research results to the practicing farmer with the very slow progress in medicine. As far back as 1862, when the Department of Agriculture (USDA) was first created, the Morrill Land-Grant College Act was passed, which created the first link in a direct communication chain from the federal and state governments to the farmer in the field. The Hatch Act of 1887 provided grants to states to support experiment stations for agricultural research and development. There was nothing like this in medicine. In 1914, county agents, operating from the experiment stations, were authorized to advise farmers on agricultural matters. Thus scientific information from the laboratory was rapidly disseminated at the place and time it was needed. The new communication modalities were early exploited: in 1920 market news was transmitted by radio in Morse, and the next year saw the establishment of a regular program for farmers broadcast from the world's first broadcasting station

in Pittsburgh. This was followed, in 1928, by a nationwide agricultural program, broadcast from Chicago. In 1946 a regular television program for farmers was inaugurated in Schenectady. This was all backed up by massive infusions of instruction and literature. Farm equipment manufacturers had provided instruction and literature since 1910, while instruction in livestock improvement was started by packing companies in 1917, and in better seed-handling methods by seed companies in the 1930's. The report ascribes the tremendous progress in agriculture to its communication network, based on 72 land-grant universities and colleges, 53 experiment stations, 6000 county agents, 95,000 4 H Clubs (which encourage scientific agriculture among farm youth), 120,000 USDA employees, and 50 state departments of agriculture with information outlets in the form of over 700 farm journals and newspapers, 1000 radio stations, 400 television stations, and 200 farm organizations.

The lessons for the Biomedical Communications Network are clear; but how is the doctor to be persuaded to abandon his long-time conservatism?

New ways of packaging and disseminating knowledge to the medical profession are needed to insure that the practitioner of the future has the information he needs when he needs it and, as new information is generated.

RM 1 provides perspective for the BCN systems designer in the

Library Services Component. It is a prefatory statement concerning the historical development of the field of medical libraries and communications. Included are vignettes of past failures and successful attempts to make the information content of medical literature more directly available to the practicing physician, and the medical researcher and educator.

RM 2
HEALTH SCIENCE
LIBRARIES TODAY

The purpose of Health Science Libraries Today (see RM 2) is to present a picture of the nature and extent of biomedical communications as it occurs in the medical world through institutional libraries and information centers. It is a factual study prepared for the systems designer of the resources and shortcomings of existing health science libraries and an evaluation of their effects on the national health effort. In addition, the report includes a suggested plan for interconnecting health sciences libraries into a biomedical communication network.

During the past 15 years, a number of surveys have been made of health science libraries. Most of these focused on the activities of libraries at medical schools. In recent years, however, special surveys were conducted of institutional libraries in fields allied with medicine--hospital libraries, nursing libraries, and others.

Despite these reviews, there exists very little information about the basic characteristics of medical libraries and even less about the standards by which their value to the field of medicine is measured. This report therefore is designed to present a more complete understanding of the relationships health

sciences libraries have to the full domain of medical experience and practice.

There is no doubt that health sciences libraries will play an active and probably innovating role in the development of the national biomedical communications network. Traditionally, these libraries have represented the primary sources of medical information and their roots are deeply embedded in the educational and research processes of all the health professions.

For this reason it is essential to develop as comprehensive a view as possible of the health sciences library community. Advance knowledge of the location of health sciences libraries, their geographic distribution, their facilities, their collections, their use of the new media, their clientele, and their cooperative undertakings is a prerequisite to network planning.

RM 2 offers the most comprehensive review of the subject to be presented in a long while. It provides a quantitative summary of medical library facts, an analytical review of function and services, and a very complete bibliography. It reveals that health sciences libraries are unevenly distributed across the country, with numerous and rich collections concentrated in the metropolitan centers while other areas are virtually devoid of biomedical information services. It points out that facilities, where they exist, are limited, and that most health sciences libraries have outgrown their physical quarters. It indicates

that few health science libraries have developed long-range programs embracing the newer media. And it exposes the need for much greater cooperation and communication among health sciences libraries if they are expected to function as an "information community" in support of medical research, education, and practice.

These findings of course antedate the Medical Library Assistance Act (1965), which was designed to remedy some of the above mentioned ills; but its benefits are yet to be felt. RM 2 makes it crystal-clear that medical libraries can and should become an important element in a national biomedical communications network. To do so, however, they must be strengthened and supported on a continuing basis for some time to come.

Of special interest in the report is a description of how health science libraries meet and support the information needs of practicing physicians, physicians with teaching responsibilities, research-oriented physicians, biomedical scientists, medical students, paramedical personnel, and other individuals who function as part of the allied health professions. For each of these users the report sets forth a vignette of their interaction with sources of medical information.

Because a future biomedical communications network will undoubtedly strive to serve individuals directly, the report places considerable emphasis on the information habits and needs of the practicing physician. Interviews were conducted with a

number of general practitioners and specialists with the object of obtaining greater insight into their information-seeking behavior, and a detailed treatment of their responses is included as a supplement to the report. In particular, EDUCOM wanted to learn in greater detail about the information sources which practicing physicians routinely consult during a typical working day and what, if any, retrospective use they make of the library. From these interviews, the report concludes that a definite requirement exists to increase the responsibilities of tomorrow's medical library network so that it can play a more practical and more active role in providing information directly to practitioners.

Since pre-Christian times it has been true that physicians who wanted to use a library effectively had to visit it personally. However, the ever-accelerating tempo of the twentieth century is likely to deny the physician this opportunity because of lack of time. This trend will probably continue rather than abate. Consequently, it is appropriate to consider establishing some new communication channel between physician and library that will allow medical information to be conveyed to his office or home in a timely and efficient way. While recent advances in electrical communications have made such communications technically feasible, it is not yet clear what information should be transmitted over these channels or how the telecommunications network should be organized in order to make the library's total information

resources most available to the physician. The interviews shed considerable light on these unknowns and the reader's attention is invited to the basic data (see RM 2, Appendix B).

Even though the interviews constituted a very small sample of physician reaction, they quickly established an information dichotomy which is likely to be maintained in the future, namely, that the nature of physician information needs can be classed as being immediate and continuing. Dr. William H. Stewart, Surgeon General of the United States Public Health Service, speaking on "Health and the New Technology" at EDUCOM's Conference on Educational Communications at Duke University in 1966, stressed the difference between the two needs when he said, "I am particularly concerned about...the practitioner of medicine, who is at the end of the line. . . , whose job is one that (relies on a) minute-by-minute need for information which he can't predict he will need at a particular moment." About the physician's continuing need for information he said, " [the physicians] are also responsible in large part for communicating with the oncoming generation [of medical practitioners] in their own like who are going to communicate with one another and they need the information for this purpose."

Immediate refers to the kinds of information a physician normally obtains from desk handbooks, pharmaceutical looseleaf service, county health department releases, drug detail men, the poison control network, person-to-person communication, and so forth. It is "hard" information and it is immediately useful to

him in patient care. It is information that he needs all day long and which he trusts will be current and accurate. Continuing information, on the other hand, can best be described as the classical literature a physician is accustomed to using when he consults bibliographic sources in the library. It includes the journals, the monographs, and the society publications which form the professional foundation for all medical knowledge. Although the practicing physician may refer only infrequently to this source for immediate information, it in no way affects his general view of the library as an indispensable source in the medical research and educational process.

Systems analysts planning a biomedical communications network can learn much from direct interviews with practicing physicians. Such interviews are highly educational and they inject realism and practicality into systems design. A few hours in a doctor's office very quickly gives the interviewer a "feel" for the kind of functional system which will truly help the practicing physician do his job. From RM 2, and other sources, EDUCOM has gradually built up the following description of the practicing physician and of his reliance on information:

The practicing physician may first and foremost be characterized as the man "with little time". He usually has a large and busy practice and makes hospital rounds, and, in some cases, house calls. Time is short, and his information needs, critical as they may be, cannot compete with time

devoted to patients. He sees drug detailmen during his busy day and considers them an important source of information on new drugs. Drug firms inundate him with free material, brochures, house organs, and the like, and he feels that he must read most of this material to be informed on current medications. He subscribes to journals, (usually between four and ten titles), and reads these when he can to "keep up". When he is baffled by a diagnostic problem, he picks up the telephone to call a colleague whom he trusts. Sometimes, when he finds a review of a book that is critical as well as descriptive and tells him something about the book, he buys it. He relies heavily on a number of handbooks, the most important of which is Physicians Desk Reference. This volume, published annually, and supplemented quarterly, supplies him with information on drug names, dosages, side effects, and the like.

He attends what meetings he can, mostly out of town, so that he can devote his attention entirely to what is being presented, and does not have to worry about the omnipresent telephone. Sometimes, when he feels that he needs to read something more than is presented in his journals, he goes to a nearby library. As a rule, he is not aware of the various indexes or abstracts beyond those he used in medical school. Current Contents, Science Citation Index and the various continuing bibliographies and specialized abstracts are not

known to him. He often continues to rely on the library of the medical school from which he graduated, but if he has moved to another area, he does not always realize that he can use the nearest medical library there. While in the hospital he may drop into the hospital library, but he may find that what he needs is not there. The farther away he is from library resources, the less likely he is to think of them as an information source.

He generally feels that he keeps up as best he can, and that his information needs are reasonably well met. He complains of the multitude of printed materials that come across his desk; "separating the chaff from the wheat" is a time-consuming task and he wishes that somebody would do it for him. He would particularly like more review articles; current, concise, and presenting only the best writing. When he learns of the various selective dissemination techniques available, either on a manual or automated basis, he feels that a service such as this, tailor-made for him, would be extremely important, would save his precious time, and would, he hopes, perform the evaluative function for the literature which he desires.

He believes in the importance of continuing education for practicing physicians but his reaction to seminars and meetings is varied; some are too theoretical for him to be of immediate

value, although he recognizes that theory ought to be part of the continuing education function. When given a choice, he prefers the practical approach, in seminar form; there he can ask questions and benefit from the discussions of the group.

The average physician in the United States is a solo, private practitioner who owns his office, employs one or two assistants, is affiliated with one or two local hospitals, sees a total of 110 patients per week, 91 in his office, 18 in the hospital, and one at home, works 50 to 64 hours per week, has a net profit of \$26,680, an operating overhead of 60% to 70%, faces an improving financial situation but a rising overhead, faces a slight improvement in physician-to-population ratio, and is considering joining two or more local physicians in group practice.

The economics of medical practice and the level of paramedical support vary according to institutional affiliation. Solo and group practitioners divide their time between office and hospital. Clinic physicians are full-time employees and do not engage in private practice. Teaching associates practice in offices provided by the hospital.

The pattern of physician behavior also varies as a function of solo or team practice and generalization or specialization. For example, Mayo Clinic and Cleveland Clinic advocate team approaches to diagnosis. Mayo and Cleveland are also predominantly referral

centers. The University of Minnesota and Kaiser Permanente in Oakland, California, have introduced screening techniques and are now training medical interviewers who will specialize in interpreting screening information.

Information used by a physician is developed through the diagnostic method. It is this process that sets the first rule for the design of a system to serve physicians.

In 1963 Crombie⁽¹⁾ described the computer in the diagnostic process as a store of estimates of the probabilities that given symptoms will be associated with specific diseases. In that same year, Engle and Davis⁽²⁾ wrote a series of papers on the past, present, and future of medical diagnosis. In 1966 Trueswell⁽³⁾

(1) Crombie, D.L., M.D., "General Practice Today and Tomorrow," The Practitioner, Volume 191, October 1963: 539-45.

(2) Engle, R.L., Jr., and B.J. Davis, "Medical Diagnosis: Present, Past, and Future. I. Present Concepts of the Meaning and Limitations of Medical Diagnosis," Archives of Internal Medicine, Vol. 112, October 1963: 512-9.

Engle, R.L., Jr., "Medical Diagnosis: Present, Past and Future. II. Philosophical Foundations and Historical Development of Our Concepts of Health, Disease, and Diagnosis," p. 520-29; III. Diagnosis in the Future, Including a Critique on the Use of Electronic Computers as Diagnostic Aids to the Physician," p. 530-43, "Archives of Internal Medicine," Volume 112, October 1963.

(3) Trueswell, R.W., and A.H. Rubenstein, Program of Research on the Management of Research and Development--Information Searching Behavior of Physicians, Department of Industrial Engineering and Management Sciences, Northwestern University, Evanston, Illinois, October 1966.

and Rubenstein⁽⁴⁾ attempted to convert this process into a formal diagram showing relationships, input, and results of data used in the patient care process.

The average private practitioner completed four years of medical school and three years of internship and residency approximately ten years ago. For new information on medications, diagnoses, therapy, and patient care techniques he depends strongly on colleagues and others who have had clinical experience with that information.

The physician belongs to one or two colleges or boards serving his area of medical interest, reads their publications, and supplements this intake by attending lectures arranged through the hospital to which he belongs or through the local medical society. For a subscription costing \$70 a year he can receive commercially produced audio tapes. If he is not a surgeon or anesthesiologist and is in a metropolitan or near a metropolitan area he may view special TV broadcasts of medical lectures. The courses that he does attend are short, concentrated bursts of instruction designed to fit in his practice schedule.

(4) Rubenstein, Albert H., Gustave J. Rath, Richard W. Trueswell, and David J. Werner, Program of Research on the Management of Research and Development, Department of Industrial Engineering and Management Sciences, Northwestern University, Evanston, Illinois, October 1966. This paper is based on a talk presented at the Twentieth National Conference on the Administration of Research held October 26-28, 1966, at Miami Beach, Florida.

Experimental medical techniques, advanced clinical or animal research, and advances in tutorial methods are treated casually by the practitioner. His immediate interest is in clinically confirmed medical experiences. The fact that these experiences are not analytically and rigorously controlled is not so important to him as to his colleagues in the allied sciences of biology and chemistry.

These data are heavily pictorial in content and narrative in form. The narrations are designed to provide the physician with extensive descriptions and therefore, a vicarious appreciation of the information.

Some primary rules can be developed from the knowledge of information-seeking behavior of physicians. The information system serving the private practitioner must be based on a request-to-response design attitude. The total transfer function of the system must include all facets of the turnaround cycle, including the search and retrieval function, the location of information, the transfer of the request to that data location, the determination of data availability, and then delivery to the requester.

The system must accommodate data in all forms and of all lengths. Versatility of handling is a key design requirement.

The Biomedical Communications Network must handle a variety of data forms and multiple length messages. It can be assumed that a number of communication media will be used. There will be three

basic message forms: 1) A direct response; 2) a call back; and 3) a mail back.

A well-structured file, a distinct inquiry, and a short reply will be handled within a three-minute period. Some poison inquiries will be direct reply messages. Not all poison inquiries will fall into this category and the more complex may be referred to a laboratory. "Mail back" replies will typically include materials, such as films, which are not easily transmitted.

The aggregate system will be an expanding intermingling of information sources and physician users. Each primary source used by a physician will have a complete system information directory. The directory will be similar to a union list. The directory will be supported by a circulation control record which will notify the requester of data availability. In the event of nonavailability the request will be switched over to a second source. That source will transmit the data to the user. The expanding network will extend from user-to-source, from source-to-second source, and from user-to-user.

The network will include multiple media of multiple length located at various centers. A spirit of cooperation between participating institutions and a certain degree of commitment must precede the establishment of such a network. Although no systems now handle such a variety of data, there are examples of networks which illustrate the trend in cooperative ventures.

In sum, the excursions to physician's offices demonstrated that there are certain reference information-type services which a biomedical communications network can provide directly to the physician in order to help him conserve his professional time and thus allow him to see more patients. RM 2 ends with the conclusion that health science libraries should be considered charter members of any future biomedical information system designed to serve the practicing physician. It recommends a hierarchical relationship among health science libraries through a network configuration consisting of primary libraries (the library available locally to the physician); district libraries (of medium size and serving many primary libraries); reservoir libraries (serving the needs of a region with a comprehensive collection and larger services to support education and research); and the National Library of Medicine as the apex of the pyramid).

The network of libraries proposed in the report is highly user-oriented. It is based not only on a quantitative and qualitative analysis of the different types of users and their geographical location, but also on the use of new channels of communication, and on methods for obtaining feedback from users to make any future biomedical information network more and more responsive.

RM 3
SURVEY OF INTERLIBRARY
COMMUNICATIONS SYSTEMS

Interlibrary communications describes the nature of electronic and other communications methods and practices that have been used during the past 15 years. It provides the Biomedical Communications Network with hard information about the experience of others engaged in the planning of more effective communication between and among libraries. Written in the form of a bibliographic essay, RM 3 traces the development of computer and communications technology in cooperative library systems and, in the process, gives special emphasis to the experience of medical libraries.

A variety of different communication forms are highlighted. They range from the simplest use of the U.S. mails up to the telephone, teletype, radio, and even remote access computer-operated systems. Each historical vignette is supported by a bibliography and detailed substantiating facts.

Of all of the different kinds of equipment used by libraries for interlibrary communications, the one which has received widest acceptance for its practical value and immediate usefulness is the teletype machine.

The earliest use of the teletype machine in libraries took place in 1927 at the Free Library of Philadelphia. The machine was part of a closed circuit teletype system used for communicating book request information from the loan desk to the stacks and vice versa. Following World War II, the first installation connecting

two distant libraries was established between the Milwaukee Public Library and the Racine Public Library in Wisconsin. Racine's limited collection was considered inadequate to the demands of its patrons and, rather than increase the book budget significantly, its Director negotiated an access arrangement with the larger collection at Milwaukee via teletype. Daily messenger service was instituted between the two libraries to effect pick-up and delivery of library materials.

The teletype machine enabled the libraries to use the speed of the telephone with the authority of the printed word. This advantage continues today and is the one which is mainly responsible for the proliferation of teletype communications. Teletype communications between and among libraries are beginning to emerge in both informal and formal network configurations. In addition to their obvious application to interlibrary loan, teletype has also been used to augment library holdings on a reciprocal basis to provide for general communications with other libraries, to serve as a channel for querying union catalogs, to accommodate reference questions and services, and to handle internal communications.

Within the past few years, Warren Bird at the Medical Library, Duke University, established the protocols for a teletype interlibrary loan network which connects six medical libraries with the National Library of Medicine. Mr. Bird produced a procedures manual to govern the use and operation of the network and also adapted the American Library Association's Interlibrary Loan Code

to the communication processes.

Perhaps the most important benefit to accrue to users of medical library teletype service is the immediate ability it provides to communicate with any other teletype user anywhere in the world. Thus, it becomes possible for any participant in the Duke teletype network to communicate reference inquiries to information points outside the formal network. As reference demands increase, it is likely that medical libraries will begin to make wider use of the teletype machine even though it may have been initially acquired for an entirely different purpose. In addition, expanded uses in the future are a virtual certainty both because of the low cost of teletype operation and the technical improvements in the equipment itself.

In general, RM 3 reveals that, although the advantages of advanced means of communications have been known to medical libraries for many years, their utilization has been retarded by questions of cost and systems planning. Implicit in the report's conclusion, however, is that the development of computer and communications technology and of regional and national library network programs, when combined with the day to day pressure for increasing services, will cause libraries to devise more effective ways of applying communications technology so as to facilitate interinstitutional services.

RM 4
RATIONALE AND NODE SELECT-
ION FOR INITIAL PHASE OF BCN

This report further develops the discussion of the Library Services Component of the Biomedical Communications Network. An essential step in the planning of a communications network is developing acceptable rationale for selecting the individual nodes which will comprise the net. This step can only be taken, however, after the role and functions of each component of the network are clearly defined and well understood. Thus RM 4 sets out (a) to identify the library functions and activities to be considered in planning, (b) to classify existing facilities as candidates for inclusion as nodes in the system, (c) to suggest minimal requirements for participation, (d) to estimate the manpower, resources, and cost implications, and (e) to outline a general plan for implementing the initial phase of Development of the Library Services Component. RM 4 specifies the library activities to be included and selects specific libraries for participation in the initial phase. The proposed Biomedical Communications Network (BCN) is defined in the report as a set of libraries, selected by NLM, and interconnected by electronic links primarily to afford wide access to computerized user services or support services now available at only a few institutions.

Included in RM 4 is a chart developed for the national survey of medical school libraries detailing user services, and another listing support services performed for one library by another.

Direct user services, performed for patrons of that library, are differentiated from indirect user services performed for another library. A user service corresponds to a specific request, while support services cover a wide spectrum of general services with no one-to-one relationship.

An hierarchical model, based approximately on the four levels of libraries envisioned in the Technical Development Plan, and including the users, is presented. Quantitative data are at present available only for "on demand" provision of specified documents; for the total volume of service requests, which could be more useful in estimating the computer and communications capability required at each level, data are not at present available.

The model estimates the number of elements at each level. Level 1 is the national facility (NLM), Level 2 comprises the 10 regional facilities, Level 3 the 100 subregional facilities, and Level 4 the 1000 local facilities (closer to 10,000 if all document collections called libraries are included). There are 100,000 potential users, (closer to one million if nurses, dentists, and allied health professionals are included). For each level the direct and indirect demands are stated, expressed as a mean number per element, and as a ratio.

The model does not take into account the fact that some regions have no Level 2 facility and that in such a region a consortium of Level 3 facilities may be approved as the regional library (e.g.,

East Central Region--Michigan, Ohio, and Kentucky). Where a Level 2 facility exists, the role of Level 3 facilities has not been defined; in other words the system seems to be evolving as a three-level one, rather than as a four-level one.

Minimal requirements for BCN nodes at each level are then presented, in terms of budgets, materials, service tools and staff. Tentative budgets of \$300,000 for Level 2, \$30,000 for Level 3, and \$3,000 for Level 4 facilities are postulated. In materials, Level 2 is seen as having more than 2,500 current serials and, generally, more than 100,000 books; Level 3 more than 250 current serials and over 10,000 books; and Level 4 more than 25 "essential" current serials and over 1,000 books. In service tools, Level 2 is pictured as having all "standard" document, citation, and answer service tools; Level 3 the "major" ones; and Level 4 the "essential" ones. In staff, Level 2 is expected to have over 10 full-time professionals with, usually, an equal number of clerical and technical staff; Level 3 more than quarter time of an "adequately" trained individual. Operational definitions of "adequate", "essential," "major," "minimal," and "standard," are not given although they will surely need to be developed.

The functional role for Level 2 is to provide indirect services and support services to an NLM-designated multistate area (estimated at 10 Level 3 facilities, 100 Level 4 facilities, and 10,000 users), and direct services to users lacking other

facilities. Level 3 is to provide similar indirect services either to a specific geographic area or to a specific group of Level 4 facilities (generally 10 facilities and 1000 users) and sometimes some direct services (as at Level 2), while Level 4 is seen as providing direct services to its own user population and limited system services to other Level 4 facilities in the area.

In a series of tables, facilities in regions with approved or funded programs as of October 1, 1968, are classified at the various levels and compared with the previously specified minimal requirements for BCN nodes. These regions are I (New England), II (New York), III (Mid-Eastern), IV (Mid-Atlantic), V (East Central), VII (Mid-West), and X (Pacific Northwest). Data given include, for Level 2 facilities: name, number of interlibrary loans per year, automation plans, and whether the facility has TWX (Table A). For Level 3 facilities: total number in each region, libraries of health science schools being in Table B, and libraries of medical societies, hospitals, and other organizations (subdivided into profit and non-profit) in Table C; for each health science school facility, the name, median borrowing time, annual number of interlibrary loans, number of professional staff, automation plans, and availability of TWX are noted. For the other facilities, the type, the name, the location, the number of serial subscriptions, the number of professional staff, and the availability of TWX are included. Table D has an estimate of the number

of hospital libraries in the same regions which would probably meet Level 4 requirements. Data given include: the number of American Hospital Association (AHA) members, the number accredited by AHA, the number approved for residency training, the number affiliated with a medical school, and estimates of the number with libraries, of the number of libraries with staff, and of the number of librarians requesting interlibrary loans (taken as the criterion of whether the library is "adequately" staffed). A forthcoming AHA survey should provide more accurate data.

Libraries of schools of nursing and of other allied health professions were not considered in the report; these would number several hundred. The biomedical document resources of large general libraries were also not taken into account. Some groups of users have special problems. Dentists, for example, are a very large group with no institutional base, who need to be provided with at least "remote" access to system resources.

In order to select priority functions in the initial phase, four questions had to be answered affirmatively:

1. Can current technology materially improve the function either by making services now enjoyed by few available to many or by making possible services not otherwise feasible?
2. Are the hardware and software either available now, or so far evolved that modest developmental effort can result at least in pilot operations within two years?
3. Does the function involve either a very large volume of transactions, or a widely expressed user want?

4. Does the function represent a bottleneck limiting expansion of other services, or is it closely coupled with other functions so that improvement in volume or quality will have a major impact on these other functions?

The user service functions selected for top priority are (numbered as in RM 4):

- 1A: Packaged "Level 5" facilities managed as branches of Level 2 or Level 3 facilities, which would supply small hospitals with a basic collection, maintain this collection, and provide staff-medicated document, citation, and answer services via no-toll phone lines.
- 1B: No-toll 2-way voice channels between users with no institutional facility (especially dentists) and staff at BCN node.
- 1C: Hierarchy-dictated 2-way channels among nodes for interlibrary requests and service output.
- 1D(2): On-line computer searches of MEDLARS and multifiles.
- 1G(1): Batched recurrent computer searches of MEDLARS files on individual profiles.
- 1H: On-line and batched computer searches of multifiles.

All support services were listed to receive top priority.

They are:

- 2A(1): Computer files of regional (all Level 2 and 3) holdings data.
- 2A(2): Computer files of combined holdings/availability data.
- 2B: Decentralized cataloging input to NLM files and remote on-line query.
- 2C: Remote processing of "housekeeping" records and management data.

For the top priority functions, suggestions are also made on the levels which should be operational and those which should operate

as pilots. Certain other user service functions were listed, but not given top priority. These were:

- 1D(1): Batched computer searches of MEDLARS files.
- 1E: On-line computer searches of multifiles.
- 1F: Batched recurrent computer searches of MEDLARS files on group profiles.
- 1G(2): Batched recurrent computer searches of multifiles on individual profiles.
- 1I: On-line computer searches of multifiles.
- 1J: Computer-aided instruction for teaching use of information resources.
- 1K: Transmission of document contents (telefacsimile, etc.).

Criteria of selection for initial phase involvement included:

(a) locating a BCN node that has a regional medical library funded or approved and (b) is able to meet minimal requirements of functional responsibility. Taking into consideration (c) funding limitations, (d) need for concentrating resources, and (e) building lower-level nodes where higher-level nodes are already operating, the report suggests that not more than two regions should be involved in the initial phase. Region II (New York) and Region V (East Central) are selected for involvement, since, in New York, the State University of New York (SUNY) already has a functioning network which could participate less expensively than any other, and, in Region V, a consortium-type regional medical library (Level 3) will provide a good working environment for pilot projects at Level 4. The report concludes by recommending specific implementation of BCN projects for the first phase in these two regions.

RM 5
INITIAL PHASE DEVELOPMENT OF
THE LIBRARY COMPONENT OF THE BCN

This report addresses itself to five tasks:

1. To elicit information feedback from selected leaders in the biomedical library community regarding the rationale and plan for node selection recommended in the earlier study (RM 4).
2. To develop an approach for estimating probable traffic flow among BCN nodes.
3. To define, in greater detail, the role of nodes at each level.
4. To prepare a "strawman agreement" outlining the obligations and responsibilities that nodes might be expected to assume if they are to participate in the BCN.
5. To identify further tasks that must be accomplished to implement the initial phase of the BCN.

To obtain feedback from medical libraries, six were chosen, the Countway Library, the Upstate Medical Center of the State University of New York, the New York Academy of Medicine, Wayne State Medical School, the College of Physicians of Philadelphia, and the Welch Medical Library of Baltimore. Four of them have primary responsibility for an NLM approved or funded Regional Medical Library program. Of the two who have not, one was chosen as a "disinterested" party, the other as the foremost pioneer of networking.

The six were sent a copy of the Rationale and Node Selection plan and reactions were obtained by interview. Only minor changes

have been suggested, particularly in regard to the criteria set for minimal budget and resource requirements; no major criticism was voiced, even with regard to the controversial choice of regions for implementation. This general concurrence gave tentative assurance that the plan was sound and ready for further exposure to interested parties.

The basic approach to estimating possible traffic flow was the use of available data on current service demand to predict the total messages that will have to be handled in the demonstration regions. The report points out that such data is scarce and incomplete.

Interlibrary loan figures provide the only available data. On the basis of a survey made in Region III (Mid-Eastern), the annual number of requests to NLM is known, as is an estimate of borrowing from all sources. Hence a figure can be obtained for the proportion of NLM requests to total borrowing. Using a corrected form of this, estimates of total borrowing in other regions can be derived from the number of requests made to NLM by that region, assuming that the proportion of NLM to total borrowing is the same in all regions (Table 1, RM5). This obviously does not hold for Region IV (Mid-Atlantic), and it is further assumed that NLM provides 50% of the loans in this region. When this correction is made, total borrowing is estimated at 910,000 requests. Table 2 of the report relates the demand in the various regions to parameters such as percentage

of practicing MD's, of approved residencies, of AMA-accredited hospitals, of medical school affiliated hospitals, and of PHS research and training funds. Good correlation suggests that the assumptions underlying this method of estimation are essentially valid.

Further predictions are then made on the distribution of demand at various levels, using Region II (New York) as the example; a ten percent annual increase is assumed. This gives a base of 194,000 total requests for Fiscal 1970. Fifteen percent of these will be generated at Level 3, the remainder at Level 4. Level 2 will then receive all Level 3 requests (assuming no inter-connection between same-level nodes) and those requests from Level 4 unsatisfied by Level 3, assumed to be 10%. This means that Level 3 to Level 2 channels will carry 45,000 requests in all or average about 1000 to 2000 requests per channel, depending on the number of nodes. Similarly the channels between Levels 3 and 4 will carry about 165,000 requests assuming several hundred Level 4 nodes. If the regional library can supply better than 85% of the requests, this would mean a maximum of 7000 passed on to Level 1 (NLM).

Very tentative estimates are also made of the demand for the user and support services listed in Table 6 of the earlier study (RM 4). These must necessarily be tentative since there are no studies on which to base the estimates. Interlibrary loan is the only measure for which detailed figures exist.

The role of nodes at each level has been defined further in terms of consumer versus supplier function by considering the general nodes providing a broad range of system services. When tapping the resources of other nodes, a node is a consumer. On this basis nodes at Level 4 are expected to devote resources to supplier versus consumer in the ratio of 1/100. Level 3 nodes providing system services to a group of between 5 and 30 Level 4 nodes should be furnishing indirect services to a user population of about 1000. They may also furnish library support services and direct services. The proportion of effort at Level 3 to supplier versus consumer activities will range from 1/10 to 1/100.

Level 2 nodes are expected to provide backup services to about 10,000 users, as well as library support services and direct services. Supplier to consumer effort will generally range from 1 to 1/10, but may in some regions approach 10, in the case of the "libraries' library".

Since NLM will be dealing with requests that lower levels have not been able to fill, its role is likely to be quantitatively different.

On the basis that the aim of the BCN is to equalize the biomedical community's access to library services while upgrading the services available, the report postulates five requirements for agreements: (a) that its own institution should maintain or increase the support received by each node as total support for the network increases; (b) that users' demands are met at the lowest appropriate

level in the network; (c) that network compatibility is assured; (d) that data necessary for monitoring the network's function are collected; and (e) that each node in the network is responsive to the needs of the levels it serves.

Since specific agreements can only be worked out in the context of a particular region and of a particular stage of network development, only general principles of agreements are detailed between nodes at one level and those at the next lower level. Responsibilities as a consumer will include maintaining resources at specific standards, observing rules in referring unmet requests to higher levels, and supplying data on resources, direct services, and consumption of system services to higher levels. As a supplier of system services, a node will have to meet minimal standards in providing services to lower-level nodes, to observe rules in passing on unmet requests to higher levels, to supply data to higher levels on system services, to develop a mechanism to insure responsiveness to lower-level needs, to provide direct user services to those without other facilities, and to provide specified system services to specific nodes. These last two responsibilities are appropriate for all Level 2 nodes and may be also for some Level 3 nodes. The requirement to supply data to higher levels on system services is the only supplier requirement appropriate for Level 4 nodes. At present, to determine responsibilities, minimal requirements for expenditures, materials, service tools, and staff will

have to be used. In the future, more relevant measures can be determined.

Difficulties can be foreseen in specifying maintenance of appropriate institutional support where a Level 2 node is already a wholesale library; in specifying responsibilities of nodes which are part of other library systems; in specifying eligibility for free indirect user services; and in deciding how much standardization within and between regions is desirable and necessary.

The report suggests five other tasks to take priority:

1. To involve medical library leaders. First, a 2-day meeting of NLM staff and the 6 librarians already involved in the feedback process, to produce a paper for discussion by Regional Program policymakers and thereafter the MLA membership, so that feedback may be obtained.
2. To closely work with regions selected for the demonstration phase to work out agreements, priorities, schedules, and specifics, and decide how special facilities (such as industrial libraries) can be tapped, and investigate such possibilities as automated citation verification with MEDLARS and Current Catalog tapes. These will provide a sound basis for implementing the plan.
3. To develop criteria and cost-benefit measures for evaluation, collection of base-time data for evaluation, and design of a program for obtaining follow-up data.
4. To establish a conceptional framework and data for computer simulation of network traffic.
5. To conduct logical analysis of how the library component might articulate with the other components and share common links, files, programs, and hardware.

All these require only small expenditures now, and could insure that a rational network evolves. Later this may be very costly

and may be impossible to achieve.

This report takes the Plan for the Library Component one stage further.

MODEL BCN
MANAGEMENT FILE

As part of the research effort to develop the Library Services Component of the Center for Biomedical Communications, EDUCOM, in collaboration with TECHNETICS, INC. a sub-contractor, prepared and tested a working model of a medical facility information retrieval program.

Data on 12,000 medical facilities, i.e., hospitals, clinics, libraries, and so forth, were identified, selected, and organized into machine readable files for use with an on-line, computer-controlled remote inquiry system.

The project had several objectives:

1. To provide the Biomedical Communications Network with experience in loading and using a structured information file relating to the medical community, and operating on it in a communications mode
2. To develop a keener appreciation of the kind of language and file organization to be used ultimately by the Biomedical Communications Network, and
3. To organize on tape a common data base on medical facilities which could then serve as a management file available to all Biomedical Communications Network subcontractors for planning and development purposes.

In support of this modeling program TECHNETICS was assigned the task of collecting data on an estimated 10,000 to 15,000 medical or medical related facilities* and entering these data into the remote inquiry LUCID programming system of the System Development Corporation in Santa Monica, California. Fifteen elements representing basic descriptive and location information were coded for every facility. Additional elements of descriptive information were collected where available and these varied in number and form with facility type.

The procedure involved location of source materials, design of coding forms, transcription of the data from input documents to coding sheets, key-punching of coding sheets, programming of some existing machinable data to correct input format, and the conversion of punched cards to magnetic tape input for final transmittal to SDC.

A total of 12,000 medical facility records were created. The following section describes the elements comprising each file, sources used for each element of data, some suggestions for a different approach to the handling of the data, and finally, recommendations for maintaining the files on a continuing basis.

*A facility, as used here, is a functionally distinct site of activity, and may be located within, or in close proximity to, another facility. For example, a hospital and the poison control center maintained within the hospital, are here counted as separate facilities.

Files

Five separate files were created containing data on the following facility types (number of records is shown in parentheses):

hospitals	(7234)
medical clinics	(193)
medical colleges	(98)
medical libraries	(999)
poison control centers	(542)
information centers	(28)
federal biomedical laboratories	(74)
nursing schools	(1109)
dental schools	(54)
optometry schools	(12)
schools of physical therapy	(56)
schools of inhalation therapy	(117)
schools of practical nursing	(1438)
schools of x-ray technology	
schools of occupational therapy	
schools for medical technicians	)
medical record librarians	(29)
medical record technicians	(15)

Data Elements

Elements appearing in all records are called "common" data elements. Those peculiar to one or more files are called "special" elements and are discussed separately, file-by-file. The source from which an element was taken is shown by number. The number relates to the List of Source Documents shown on pages 65-66.

Common Data Elements

Each facility record contains the following items of information:

1. facility number - a number, unique for each facility, assigned arbitrarily during coding.

2. activity code - a 2-digit number assigned as follows:
 - 10 hospitals
 - 11 medical clinics
 - 20 medical colleges
 - 30 medical libraries
 - 40 poison control centers
 - 50 information centers
 - 60 federal biomedical laboratories
 - 21 nursing schools
 - 22 dental schools
 - 23 optometry schools
 - 72 schools of physical therapy
 - 73 schools of inhalation therapy
 - 74 schools of practical nursing
 - 74 schools of x-ray technology
 - 74 schools of occupational therapy
 - 74 schools for medical technicians
 - 76 schools for medical record librarians
 - 77 schools for medical record technicians
3. regional medical program number (15) - first number from source document for county in question.
4. regional medical program number (15) - second region number for same county, frequently not used.
5. state code (13, 7) - 2 digits.
6. county code (13, 7) - 3 digits.
7. congressional district (9) - 2 digits, 00 stands for "at large".
8. zip code (14) - frequently available with name-address.
9. latitude (11) - no direction coded, accurate to city.
10. longitude (11) - no direction coded, accurate to city.
11. name and address, zip code, phone (*).
12. BCN contact, name phone (*) - person to contact on network questions.

* From basic source document applicable to facility.

13. hospital region code (15).
14. BCN level - for future use to describe relative position in network, now set to 0.
15. control code (13, 1) - 2 digit code representing major source of funds on control for facility, coder supplied where not explicitly defined.

Special Data Items

Hospital File: Each hospital data record contains 37 special elements (for a total of 52) taken from the AHA Computer Source Tape (13). They are the following:

16. hospital type code - 2-digit code designates hospital as general, institution-based, psychiatric, tuberculosis, etc.
17. stay code - code 1 indicates short-term hospital, 2 indicates long-term.
18. number of beds.
19. number of resident MD's and DDS's.
20. number of interns.
21. size of full-time MD-DDS staff.
22. other full-time staff.
23. total full-time staff.
24. size of part-time MD-DDS staff.
25. other part-time staff.

- 26. total part-time staff.
- 27-42. 16 yes-no indicators for services such as pathology lab., dental facilities, pharmacy.
- 43-52. 10 yes-no codes for accreditation and approval.

Medical College File: Eight special items were coded for medical colleges, most from the AAMC Directory (8).

- 16. school type - a code equal to 1 for fully accredited, 2 for provisional.
- 17. enrollment.
- 18. number of graduates in 1969.
- 19. number of continuing education courses (17).
- 20. size of basic course staff.
- 21. size of clinical course staff.
- 22. yes-no code for educational TV (20).
- 23. dean's name.

Medical Libraries: Seven special elements are coded for libraries. Numbers 16-21 were taken from source number 2.

- 16. type - an independent library is coded 1, a hospital-related library is coded 2, and a university-related library is coded 3.
- 17. number of related medical college or hospital (item 1 from list of common elements) where item 16 is 2 or 3.

18. size of staff.
19. number of bound periodical volumes.
20. number of subscriptions.
21. number of books.
22. capability index (19).

Nursing Schools: Nursing schools have as items 16 and 17 the total enrollment and number of graduates, respectively, taken from source number 6.

Medical Clinics: Medical Clinics show staff size (5) as element number 16.

Other Schools: All schools show dean's name where available, the relation code and related facility number (see 16 and 17 under Medical Libraries).

Information Centers: For each center, staff size (18) and a comment on the principal role of the center (18) are provided.

Approach to Handling Community Model Data

For the foreseeable future, the medical community model data base will be in a state of flux. New facilities and new elements, as well as new types of information, will have to be added and there will be a continuing requirement for updating the files.

The LUCID system has proven adequate to handle small data bases in a query mode and for update and entry through teletype.

Demonstrations of its query capabilities on segments of the total data base were well received and have demonstrated the power of an inverted processing system in value-search situations.

It is indeed unfortunate that the LUCID and similar programs provide this query capability at the expense of the update function and total file size. Two facts should suffice to illustrate the problem:

1. No update other than through teletype is possible using LUCID. If a significant new item of information becomes available for a large number of records (as will surely happen), the only practical approach using LUCID would be to regenerate entire files for all the data available.
2. It is not possible to combine all records of the data base in a single file. LUCID has internal table limitations that set absolute limits on the number of records that can be handled. As the limit is approached, update processing time becomes prohibitive. A report cannot be generated in one pass of the data, for example, to isolate records at a specific BCN level (not to mention that updating BCN level in the first place was practically impossible).

What is needed, therefore, is a batch-processing oriented system. If it also provides a query capability through a terminal, that would be an added bonus. The essential thing is that it provide for normal file maintenance procedures and handle an order of magnitude more data, in a more useful form. If necessary, or desirable, selected information could be maintained on LUCID for management or demonstration purposes.

66

Upgrading the Files

Certain elements of information are important in network

design: location, message volume in and out, message length, message content, special transmission requirements, message priorities, times of quotation, peak and off-peak load characteristics, and so on.

With location information available now, steps can be taken toward the selection of areas for study. Within whatever areas are chosen, communication requirements will have to be obtained for the facilities in question. These additional data elements should be added to the basic facility information now on hand and maintained in an up-to-date status for present and future needs.

There should also be a continuing effort to maintain the basic information in a current status along with the checking and correction of data on hand. Already, for example, there have been changes in the region designations for libraries, making some of the data on hand erroneous by current standards; and it is reported that a new version of the AHA source tape will become available early in 1969.

The addition of large amounts of new information as well as the correction of existing data would be facilitated by the adoption of a file maintenance oriented system.

As a result of the TECHNETICS sub-contract, EDUCOM delivered to the National Library of Medicine a working prototype of an on-line inquiry system for file management that is being used for demonstration as well as management purposes. The Remote Inquiry Systems Center (RISC) at NLM leases a terminal which permits

interaction with SDC's LUCID system at scheduled times during the day.

The working model enables staff and contractor personnel of the LHNCBC to: 1) utilize the hard data in the system for developmental and planning purposes; 2) train LHNCBC personnel in the use of an on-line system which is medical related; 3) increase the present capability by adding more information to the file; and 4) provide operating experience on which to base a final decision for the procurement of a more effective file organization language and system.

List of Source Documents

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7. County and City Data Book, Supplement to Statistical Abstracts, 1967, U.S. Dept. of Commerce, Bureau of the Census.
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12. Directory of Approved Internships and Residencies, 1967-68, American Medical Association.
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14. National Zip Code Directory, 1968, U.S. Post Office Department.
15. List of Medical Program Regions, N.I.H. Division of Regional Medical Programs.
16. Public Telephone Directories.
17. Continuing Education Courses for Physicians for Period Sept. 1, 1968 to August 31, 1969, JAMA Vol. 205, August 5, 1968.

18. Directory of Federally Supported Information Analysis Centers, April 1968, Panel #6, COSATI.
19. List of Library "Capability Indices" prepared for NLM Office of R&D.
20. Directory of Instructional Television Installations, 1967, Department of Audiovisual Instruction of the National Education Association.

SPECIALIZED INFORMATION SERVICES COMPONENT

- Composed of several systems:
 1. Toxicological Information System
 2. System of Information Analysis Centers
 3. System of Poison Control Centers

- Specific objectives:
 1. Identify Problem Areas Requiring Specialized Services
 2. Define Scope of Coverage in Selected Topical Areas
 3. Identify Existing Information Sources
 4. Identify Specific User Needs
 5. Establish Required Information Files and Data Bases
 6. Select File Organization, Input, Output Procedures and Query Languages
 7. Develop and Produce Specific Products and Services

- Primary Concern
 1. "Information" rather than bibliographic data

(CBC Technical Development
Plan June 1968)

RM 6
MEDICAL INFORMATION
SYSTEM-NEED AND CONCEPT

Distributing relevant information to practicing physicians is the theme of this report; it coincides with the principal objectives of the specialized information component of the BCN.

Information is important to the physician in the context of patient care and his personal continuing education. On the one hand, the physician wants to be sure that he is in possession of the most recent medical information so as not to compromise the quality of care given to the individual patient. And, on the other hand, he recognizes the personal and economic value of information and the importance of refurbishing his own professional knowledge.

There is a serious shortage of physicians in the United States; the effects of this shortage have added new emphasis to the information problem. With an expanding population, an increasing life expectancy, an ever-widening spectrum of diagnostic and therapeutic choices to be made, and a more and more complex medical world in which to function, the timely delivery of relevant information to physicians offers an attractive means by which their time can be conserved. An operating biomedical information network has the potential for providing each physician with the specific information he needs when he needs it. RM 6 points out that this may be the most immediately productive way of coping with the dilemma.

The medical profession has been greatly concerned about the alarming and still worsening shortage of medical manpower. The most direct solution to the problem is to increase the output of physicians by adding new medical schools. However, the magnitude of the undertaking and the continuing heavy demands for monetary support are a frightening prospect. Furthermore, the formation and activation of new schools does not provide an immediate answer. Every time a new medical school is opened, it imposes a drain on existing human resources, and the man-years withdrawn from patient care to form a teaching faculty are not repaid for at least 12 to 15 years. Other solutions have also been tried. For example, increasing the size of medical school classes has been advocated, and accelerated programs have been introduced. However, as yet, neither of these approaches has yielded positive effects.

It appears that solutions aimed at supplying more physicians in this way are very costly, the net gain small, and the actual effects not felt for many years. Therefore, an inviting alternative is to explore ways and means by which the efficiency of the individual physician can be increased. It is in this context that the biomedical communications network looks very attractive.

Two classes of physician information are identified and defined. The first is "strategic" information, i.e., that body of information which is a function of the physician's medical education and which is never stable or complete but must be revised, enlarged and extended as the field of medicine advances. And, second "tactical"

i.e., specific pieces of knowledge that are relevant to the physician's clinical decision-making in individual patient care (this is the area of primary concern to the specialized information component of the Center for Biomedical Communications). RM 6 stresses that in medicine there is always some overlap between strategic and tactical information and what is considered strategic at one moment can be tactical at another. For example, the knowledge that bacterial endocarditis produces emboli from the heart valves which come to rest in various locations in the body, including the ocular fundus, is a piece of strategic knowledge. At the same time, a list of causes of hemorrhagic lesions in the fundus might include bacterial emboli produced by bacterial endocarditis.

The area of tactical information, the report reveals, is the one which should be featured in a biomedical information network serving practicing physicians. The following headings are used to define the various categories of specialized information to be included (See RM 6, p. 10).

1. Prior medical or health related patient information
2. Drug information
3. Pharmacological information
4. Epidemiologic data
5. Normal values
6. Patient preparations and precautions

8. Directory of specialties and skills
9. Toxicological data
10. Bibliographic material (highly specialized)
11. Meetings and courses
12. Examinations and licensure
13. Training programs and residencies
14. Teaching or patient instructional materials

The amount of time a biomedical information network can save the physician depends on the design of the system and the way in which the physician will organize his own activities. The report indicates that there definitely will be a saving; it maintains, however, that the chief advantage of distributing specialized information directly to physicians over a network may very well prove to be the sole improvement it will bring in the quality of information, or its ability to provide information where none was previously available. It seems fairly clear, too, that the physician's specialized information needs are inextricably tied to his continuing education needs and that a biomedical information network is capable of accommodating both.

If a national biomedical information network existed and if it saved the practicing physician's time what would be the monetary worth of the saving? RM 6 concludes with the following compelling statement on the possible economic value of a biomedical information network:

"As previously implied, the saving of individual physician time is impossible to predict with certainty. If an arbitrary figure of 1/2 hour saved per physician per day is chosen, some economic estimates can be made. There are $\pm$ 230,000 physicians in the U.S., but not all are in private medical practice. There are $\pm$ 1.4 physicians per 1000 population, but slightly less than 1.0 per 1000 in private practice; therefore, 161,400 physicians ($230,000/1.4$) might be potential customers. If each of these physicians saves 1/2 hour per day and if each works 10 hours per day, 6 days a week, 50 weeks per year, the system would save time equivalent to over 6,600 full-time physicians in a year. If each physician earns \$15,000/year, the monetary saving would be over 100 million dollars per year. In sum, the economic value of saving 1/2 hour per day per physician in private practice would be over \$100,000,000 per year."

The development of a National Center for Biomedical Communications with capabilities for distributing a variety of specialized data required by physicians for clinical work, research and education, will undoubtedly be a costly enterprise. However, when

viewed from the above perspective, it is clear that such a system has tremendous economic and professional value, and that the cost of installation can be paid for many times over by the projected savings in time.

RM 7CASE STUDY OF A BIOMEDICAL INFORMATION NETWORK--
POISON CONTROL CENTERS IN THE UNITED STATES

RM 7 describes a network of specialized information centers already in existence and highlights the problems they have faced and the lessons which can be drawn from them. These are relevant in creating the Specialized Information Services component.

There are now 550 of these centers, with a National Clearinghouse for Poison Control Centers. They supply practitioners with information on toxicity of products and methods of treatment, and the lay public with first-aid instructions, and with advice on obtaining medical treatment and on procedures to be avoided. The centers are, therefore, of special interest since they constitute a specific example of an information system serving both physicians and the lay public. The questions which had to be answered for the poison control centers would also be pertinent to the Biomedical Communications Network. Where should sources of information be located? How many are needed to provide coverage? What local questions arise in the distribution of medical information? Of particular relevance is the possibility of using computers to standardize, store, and retrieve poison information; and of having telecommunication channels connecting the dispersed centers.

The poison control centers are of recent origin. The first was set up in Chicago in 1953 in response to a felt need. The success of the Chicago center led other states to set them up.

Fifteen were established in Florida in 1955. At this stage there was still no national clearinghouse and Florida provided its files to 50 localities interested in setting up their own centers. The National Clearinghouse was established soon afterwards. It is concerned with the collection of ingredient and treatment information on new and nationally distributed products, which it summarizes on cards for distribution to other poison control centers. It also collects and processes reports from centers on ingestions, and issues a bimonthly bulletin to supplement the information on the cards.

The number of centers grew rapidly to today's total of 550. The geographic distribution varies widely. Thus Maine has only one, while Illinois has over one hundred. This is a reflection of the very wide range of proposed policies, from establishing as many centers in as many hospitals as possible, to having one large center serving many hospitals. Two types of center have emerged, the information center and the poison treatment center. The information center provides information, derived from the cards or from consultants, but no treatment. The poison treatment center provides both information and treatment, and is usually located in the emergency room or outpatient department of the hospital. Ninety percent of the total are treatment centers.

Some of the centers carry out additional educational activities. In New York City, a public health nurse is sent to conduct

follow-up studies on lead poisonings. Boston, Cleveland, Detroit, and Philadelphia have active prevention programs.

The size, budget, staff, facilities, traffic, information sources, users, and scope of service vary greatly from center to center. Thus the New York City center has 15 employees while the center in Fresno, California is run by the hospital pathologist alone. The average center probably has 3000 cards and several toxicology tests. About 20,000 products would be covered in this way. The National Clearinghouse has 45,000 cards, Los Angeles 60,000, and New York City 26,000.

The number of incoming calls varies too. Some centers may receive one hundred a year; New York, on the other hand, receives about 50,000. The pattern of calls when the load becomes heavy is of particular importance in allocating the center's resources in staff.

Some pilot projects in automation are taking place. Thus the Des Moines center has been experimenting with a computer as a primary information source. Data is stored on 10,000 products. When a call comes in, the name of the product is typed into a computer terminal and the computer prints out the data on the product. This includes the toxicological type of chemical and relative toxicity; effects of various doses and likely signs and symptoms; recommended treatment; recommended laboratory tests; and the reference from which the information was prepared. Proponents of automation claim that updating this information is

simpler on the computer than on cards.

Plans for diagnostic use of the computer would involve typing in symptoms and other data and these would be compared and a possible list of chemicals printed out.

When the General Services Administration studied the poison control system in 1966, they recommended that the National Clearinghouse should use an electronic data-processing system to update its files and prepare statistical reports. A complete list of the shared information would be printed out for the use of regional centers. A random access computer was not considered necessary either at regional centers or at the Clearinghouse; high-speed film readers and microfilm were proposed.

Regional centers derive from two possibilities for a unified national network which are under discussion. Either regional poison control centers could be selected from among the existing centers and developed, or poison information could be incorporated into medical communication networks (either into the drug and toxicology information program or in due course, into something broader still). Regional centers would remove the need for the smaller centers to have coverage of all possible eventualities, so the files to be maintained could be smaller. Also, 24-hour coverage could be provided by the regional center, so that the small centers would not need to be open round the clock. Modest treatment centers could be run very cheaply in each community if

it was known that back-up facilities were constantly available.

Current centers are locally financed and opponents of regionalization claim that large expenditures will be needed which could be put to better use elsewhere. Proponents claim that maybe 300 lives a year (out of the 2000 who die of poisoning) could be saved. Thus the provision of information could be actually given a dollar value in terms of the worth of the lives saved.

Further questions need answering in order to establish a coordinated national network. How much better off is the state with 100 centers as compared to the state with one? Are data on 20,000 poisonous products adequate to cope with the estimated 250,000 which exist? Is the giving of information equivalent to treatment, and, if so, what problems arise when state boundaries are crossed? How can more complete reporting of ingestions be obtained, and how can it be determined which deaths could have been prevented?

As a viable example of specialized information centers, the lessons of the poison control centers are relevant to the corresponding component of the Biomedical Communications Network. The Poison Control Centers are the manual analog of a future mechanized medical information network and as such provide a wealth of experience that will aid BCN network design. They also represent a prime example of the life-saving qualities which a biomedical communications network could possess. For every 2000 lives lost

at least 1000 more suffer serious toxic effects under the present manual system. It is clear that improvements made possible through better communications via the BCN would save lives and eliminate misery.

SPECIALIZED EDUCATION SERVICES COMPONENT

- Specific objectives:

1. Continuing medical education to the medical professional to protect him from technical obsolescence and improve the quality of the health services he can provide.
2. Education of the medically uninformed; both in special topics of general community relevance and as a service to special groups with special health problems.
3. Education of health professionals in relevant new technologies which may or may not be peculiar to the health field, e.g., new devices, new communications media, and new procedures.

- Primary concern:

1. Directed to health practitioners who have completed their formal education.

(CBC Technical Development
Plan June 1968)

VIDEOTAPING OF CARDIOLOGY LECTURES

In May 1968, a subcontract was let to KCET, Los Angeles, Channel 28, for the preparation of videotapes of selected cardiology lectures. The lectures were part of a continuing education program sponsored by the American College of Cardiology and the Scripps Clinic and Research Foundation.

The network distribution of instructional television over the facilities of the Biomedical Communications Network is an objective of the Specialized Education Component and accordingly it was deemed desirable to test the efficacy of producing videotapes inexpensively at point of origin for this purpose.

Production setting was the Scripps lecture rooms in La Jolla, California and camera operations were supervised by an M.D. and cinematographer Dr. Richard Scott. Television equipment consisted of the standard camera and recording devices used in mobile television vans normally operated by local television stations.

The master tape contained a 10 minute introduction to the general problem of continuing education in medicine by Dr. E. Gray Dimond of Scripps; followed by lectures and audience discussion. The first lecture was given by Dr. Henry Marriott, Director of the Rodgers Heart Foundation, St. Petersburg, Florida, entitled: "Electrocardiography - Dangers of Overinterpretation". The second lecture was by Dr. Dwight E. Harkin, of the Peter Bent

Brigham Hospital, entitled: "Heart Disease and the Surgeon". The total running time for all sections was approximately two hours. The resulting two and one inch videotapes are on deposit with the National Medical Audio-Visual Center in Atlanta and available for viewing through the LHNBCB.

General benefits of instructional television accepted by the educational community fall into the following categories:

1. Multiplies the instructor's audience -

Permits live presentation to large audiences.
Permits live lectures to many remote receivers.

2. Makes scheduled viewing possible -

TV can be used as stand-in for absent professor.
TV re-runs are available for learners who miss a class or who for some reason were unable to come to the original lecture.

3. Magnifies realia -

Permits enlargement of microscopy demonstrations from the laboratory and operating room.
Permits group viewing of inaccessible areas; surgery, bronchial brushing, etc.

4. Brings distant events into the classroom -

Observation of distinguished lecturer at another medical school.
Observation of special surgical operations at a distant hospital.

The mere presentation of a lecturer on television, without careful programming, has no special educational benefit. But, if the material is carefully selected and organized, and if broadcasting environmental controls prevail, then it is possible to

produce programs of substance that are meaningful to subsequent audiences. Furthermore, when instructional television is coupled with other audio-visual aids, as was the case at the Scripps videotaping, the instructional usefulness of the end product is enhanced considerably.

Television signals can be carried by the Biomedical Communications Network over short distances by coaxial cables, and for longer distances by microwave and satellites. Videotapes similar to the type produced at Scripps can also be produced at medical schools and ultimately made available on a scheduled and non-scheduled basis to the health sciences community through the Biomedical Communications Network. While the experimental effort in specialized medical education at Scripps illuminated many technical problems, it also confirmed the practicality of using this technique on a more widespread basis.

RM 8
GUIDE TO FACILITIES, CAPABILITIES, AND PRO-
GRAMS OF MEDICAL SCHOOLS IN THE UNITED STATES

This report has collected under one cover accounts of a wide range of activities of medical schools within the continental United States. Knowledge of these activities should materially assist the analysts and designers of the Biomedical Communications Network. The information for each school is listed under four headings:

- I. Medical school data - includes the name, type of support, the enrollment, number of medical schools in that state, the school's clinical facilities, details on the medical library's monographic holdings, and key communication personnel such as the Dean, the audiovisual coordinator, the person in charge of continuing education, and the medical library director. Also under this heading are statewide statistics on the total resident population, the non-Federal physician population, number of counties, number of hospitals, and number of hospital beds.
- II. Community action programs - includes extramural library, specialized information, specialized education, and audiovisual programs for health and allied professionals and others in the area served by the medical school but not included among its usual staff or students.

III. Related activities - includes an account of the computer center, where one exists, and other programs initiated by Regional Medical Programs and others. Regional Medical library programs and MEDLARS centers are not reported since data on their activities should be readily available at NLM.

IV. The final section for each school reports on the common carrier services available. These were obtained from the local AT&T representative.

This compendium is a mine of information which should be relevant to all components of the Technical Development Plan. It will be noted that some of the data are incomplete. This points up the difficulty of collecting this kind of data, and the widespread lack of knowledge existing in each school of related programs even within its own boundaries. When it comes to the knowledge of other schools' projects, almost complete ignorance prevails. There is a need for a mechanism to circulate, formally or informally, this sort of knowledge, as early as is possible without infringing on the proprietary rights of a school. This might be a valuable service for the Biomedical Communications Network to perform.

Before preparing the compendium, EDUCOM staff visited the American Association of Medical Colleges and confirmed that:

a) no such compilation of communications related projects existed,

and b) that such a compendium would be of great value to the medical schools in development of their specialized education programs. Accordingly, RM 8 was deliberately produced in loose-leaf thus providing LHNCBC with a form that can be easily updated and disseminated should this be considered desirable.

AUDIO AND AUDIOVISUAL SERVICES COMPONENT

- Objectives:

1. To support the other CBC components by complementing the information and educational materials furnished by these other components.
2. To evolve as an extension of the National Medical Audiovisual Center.
3. To combine communications with audio-visuals in support of the continuing and specialized education of biomedical personnel.

(CBC Technical Development
Plan June 1968)

RM 9

ROLE OF AUDIO AND AUDIO-VISUAL MATERIALS IN ENHANCING
THE LEARNING PROCESS OF HEALTH SCIENCE PERSONNEL

This report is relevant to the Audio and Audio-visual Component of the Biomedical Communications Network. The increasing use of audio-visuals which has come about as a result of the simplification, reduction in cost, and hence increased availability of equipment, and the wide range of possible formats (audio, film, strip film, motion picture film, loop film, kine-scope, and video tape) has made medical school staffs aware of the benefits of their use. Biologists and nurses have been enthusiastic users for some time. Audio-visual coordinators have been appointed at 42 medical schools. Some schools have gone further and created Learning Resource Departments or Educational Resource Offices. These, besides reviewing equipment, are concerned with curriculum planning and in studying the effectiveness of the teaching-learning process, and are responsible for all forms of visual or audio instruction. Some 58 schools have appointed directors of continuing education and probably three-quarters of these have programs using audio-visual materials.

The emphasis in audio-visual instruction has been shifting from the teacher-oriented program, where the teacher projects the audio-visual and the students watch, to the exploration of ways of enhancing learning by providing easily run, self-operating machines which the student can use at his convenience. Further

interesting applications of audio-visuals are in the area of student-teacher interaction and of student and teacher evaluation. It is in individualized learning that the audio-visual has its greatest potential. There are also areas which can only be taught by audio-visual means. The recognition of these areas in advance can save the teacher much time if the necessary audio-visuals are provided.

The report then deals with some of the difficulties in obtaining and using audio-visuals. In most cases, someone else's commentary is not acceptable. This report suggests that if the audio portion (the cheaper part) of the audio-visual could be separated from the visual part, then an acceptable audio portion could be added by another user and the expensive visual portion would not have to be duplicated.

Many potential users are not aware of the availability of audio-visuals. It is very difficult to obtain information on audio-visuals, and to locate precisely what is needed, because the indexing has been either inadequate or nonexistent. There is no agreement on how audio-visuals should be indexed. There is also the question of preparing an adequate abstract, as it is normally the abstract that is used for indexing.

After locating the audio-visual, there are the financial and copyright problems of obtaining it from the producing institution. Then there is the problem of compatibility of hardware and software, though the difficulties here are largely confined to videotape and certain film cartridges.⁹³ The report stresses the need

for forethought before purchases of equipment are made.

The best use of educational programs will come when compatibility of software and hardware has been insured (a national committee might be formed to survey the problems), convenience of retrieval (including ease of operation and availability of relevant programs) has been considered, and thought given to reliability and durability of the software and hardware.

Audio-visuals are needed throughout the spectrum of health users from the physician to the layman. Obviously the material, the format, and the presentation will vary according to the user group. Audio-visuals have been applied to augmented instruction, where the teacher reinforces his teaching with audio-visuals, in dependent learning, in training the development of techniques and skills, in counseling, in self-assessment, evaluation and role playing, and in interview records. The report suggests that an educational consultant should be a key member of the total health care team. He should know what is available, in what format, for which level of learner. The report also stresses that no audio-visual program can succeed unless the program receives full administrative support.

Priorities for the Biomedical Communications Network are outlined in the report. The first is an inventory of what is presently available. Agreement on an ideal indexing format (which might never be reached) should not be awaited; instead, a crash program

using NLM Medical Subject Headings could be carried out in a relatively short time. An in-depth survey to determine the specific educational objectives of the various disciplines involved in health care should be carried out concurrently, as well as studies to determine how learners feel they learn best. When these data are available, it will be possible to determine the immediate needs for programs, and then the Biomedical Communications Network can support or contract for the necessary audio-visuals.

Regional Biomedical Communication Centers could give considerable impetus to the utilization of audio-visuals by coordinating and cataloging available materials and producing regional educational packages. Economy could be achieved by producing regional materials in a format which can be easily adapted to the needs of other regions.

DATA PROCESSING AND DATA
TRANSMISSION FACILITIES SUPPORT COMPONENT

- Primary concern:

1. To be the technical hub of the other function-oriented components.

- Areas of Interest:

1. Data and format standardization.
2. Computer software dissemination and updating.
3. Rapid delivery of hard copy.
4. Use of television and talkback services.
5. Mechanized storage for selective retrieval.
6. Generation of machine readable text.
7. Optical character recognition.
8. Communications devices, e.g., teletype, facsimile, and terminal and display.

(CBC Technical Development
Plan June 1968)

FACSIMILE TRANSMISSION

Interlibrary loan and the duplication of Xerox copies of medical journal articles for all medical libraries is one of NLM's most active interinstitutional programs. It has therefore been assumed that a future network connecting medical libraries would undoubtedly carry considerable facsimile traffic.

In order to obtain some sense of the costs involved in operating a facsimile network for medical interlibrary loan, a cost/volume analysis was made of a hypothetical network connecting NLM to libraries in nine different geographic regions. This kind of interest is germane to the objectives of the Data Processing and Data Transmission component of the Center for Biomedical Communications.

NLM's interlibrary loan statistics for 1965-66 were selected as the base for analysis of the traffic pattern and volume of interlibrary loan distribution. The analysis also assumed that there were 1500 libraries in the total network, that transmission time took 12 minutes per page, and that a flat-bed scanner was available for direct scanning of copy from the original book or journal.

Table I shows the communications line cost for distribution of NLM's present volume of interlibrary loans. This assumes that all orders are sent to the farthest points of the region. This is not true, of course, but should be a close approximation. The

column headings are sufficiently descriptive so that one could plug in different numbers, (i.e., change the volume and/or distribution) and calculate different representative network costs. Note that this chart excludes line costs for 40% of the traffic, which is assumed to be within the Washington/Virginia/Maryland area; therefore, existing telephone lines could be used at no (or modest) additional line cost. (This is an assumption that has been checked with the Washington area telephone company and the Federal Telecommunications Systems people.) To determine line costs in the abstract, the following formula is used:

$$\sum_{i=1}^9 \frac{R_i}{3750} \quad 5.4 D_i$$

$\sum_{i=1}^9$ means summation of the expression shown writing one expression for each of the nine regions.

R_i equals regional volume in eight-page orders.

D_i equals distance to farthest point of the region.

Total annual terminal cost, assuming that the number of libraries is about 1500, terminal equipment and supply costs would be \$2,200,000 with, on the average, only 20% utilization of each recorder (i.e., about five hours per day). To determine terminal costs in the abstract, the following formula is used:

$$\text{Cost} = 1440T + .20$$

T equals the number of terminals as determined by (total loans times average pages per loan divided by 3750) or total number of libraries, whichever is larger.

O equals the total number of eight-page orders.

Because of the overall 20% utilization of terminal equipment (which is deduced because no information is available on volume distribution from library to library), the actual volume per library (terminal) becomes quite critical and dramatically affect the \$2,200,000 figure--namely, can reduce it to about \$440,000 if three hundred libraries represent nearly all the traffic.

Excluded is the transmit terminal cost. This will be considerably higher than receiver terminal costs but will, in total, depend on the degree of automation you would expect to have. A starting point would be an investment of \$50,000 and operating costs of \$5000 per year or an annual cost of \$15,000.

In thinking of the mass market, such as distribution to every doctor's office, some of the assumptions and some of the cost parameters must be reconsidered. First, terminal cost would be likely to be reduced because of larger volume production of equipment. Terminal cost (T) could be as low as \$20 to \$50 per month for receiver only. Capacity of the terminal (and therefore message capacity of the communications line) could go up by a factor of 4 because of possible format changes (i.e., transmission time per page could be 3 minutes instead of the 12 used in this analysis . . . thereby reducing communications costs per message). However, the lower terminal volume would probably cause the communications lines cost to increase because the toll telephone network would

have to be used. Toll calls, at their cheapest, are about \$2 per page (to Kansas City) as compared with \$.10 per page on a private facility leased from GSA and utilized as shown in Table I.

The difficulties in costing a national system without knowing specific information about the number of terminals, volume per terminal, location of terminal and type and size of message, become obvious.

The above cost figures assume that NLM can get adequate private lines from GSA to cover the country. This probably depends on a Weather Bureau-set precedent, namely, that government installations can become the backbone of a communications system, thus allowing the modest 45¢/month/mile government line costs instead of the commercial rate of \$3.50/month/mile. Since Federal Medical Libraries represent 1/3 of NLM's volume, the idea of government-supplied lines has merit and should be explored. Once the "backbone" is established, non-government agencies or institutions can get a "drop" off the private line (at a modest cost) and have access to your library. In fact, institutions within a 3-5 mile radius of Federal Libraries could probably get a "drop" for \$20-\$30 per month.



—— "backbone" of communications network
 - - - - "drop" off the backbone into non-government institutions

Another possibility is to employ the facilities of the Federal Telecommunications Systems (FTS), which prorates its total cost equally over all terminals and at present charges about \$20 per month per terminal. This is quite modest and extremely attractive. However, FTS may not allow routine use of its facilities by facsimile. This could operate similarly to the "backbone" systems described above, because it is possible to call out to the DDD (national direct distance dial network) from an FTS terminal with only a toll charge for the DDD time/distance used. This could be estimated and prorated over all orders to the library or paid by the inquirer.

By the time any of these ideas reach reality, certain advances in the state-of-the-art may be available that would have an impact on the cost/volume parameters. The most significant of these impending developments is bandwidth compression or redundancy suppression. This will permit the transmission of more information over a fixed communication line by ignoring a portion of "white" spaces in the original. For \$10-\$20 per month extra per terminal, a doubling of input-output appears likely. For a higher cost, a 5 to 8 times input/output increase will be possible. Since most facsimile equipment can operate at these speed multiples over the private communication lines used in this analysis, the major cost reduction will be on the communication lines. . . and this can be considerable. This would enable NLM to increase its loans-by-

telephone over the same facilities with a very small cost increase.

TABLE I

NLM COMMUNICATIONS NETWORK COST WITH PRESENT VOLUME AND DISTRIBUTION

(1) Region	(2) Distribution of total Loans-Latest Available Data	(3) Present assumed loan distribution 150,000(1) x col. 2	(4) No. of 3Kc lines needed per region Col. 3-3750(2)	(5) Distance to farthest point of the region (3)mi.	(6) Col. 4 x Col. 5 x \$5.40(4)
New England	5 %	7,500	2	600	\$6,480
Mid Atlantic	15	22,500	6	300	9,720
East North Central	10	15,000	4	650	14,040
West North Central	4	6,000	2	1,500	16,200
South Atlantic (except Wash., Va., Md)	10	15,000	4	950	20,520
East South Central	3.5	5,250	2	1,000	10,800
West South Central	5	7,500	2	1,200	12,960
Mountain	2.5	3,750	1	2,600	14,040
Pacific	3	4,500	2	2,500	27,000
Wash., Va., Md.	40	60,000	see note 5	150	
				TOTAL	<u>\$106,760</u>

(1) Total loans for government fiscal year 1966

(2) Total eight-page orders that can be delivered over one 3Kc communication line operating 24 hrs/day 250 days/yr (time per page is 11.8 min.).

(3) From Washington, D.C.

(4) GSA rate of \$.45/mo/mile times twelve months

(5) Assumed to be all within no-toll, dial-up distance from NLM

RM 10
COST FACTORS OF A
COMMUNICATION SUBSYSTEM

A telecommunications system for the Biomedical Communications Network will need to integrate voice, data, facsimile, and computer requirements into a single system. This integrated media concept is an important aspect of the design of a communications subsystem but is poorly understood analytically in today's practice. The idea of an "integrated communications system" became practical only during the past few years--when the cost of computers for store and forward message switching declined and technological improvements were made in the reliability and versatility of circuit switched elements.

While many networks presently exist that carry voice or television signals exclusively, there is none which combines the various signals into a unified communications system. RM 10 was prepared to investigate the implications and provide additional insight into the design requirement. In addition, it summarized these insights into a preliminary structural model in order to simulate pricing for alternate implementation approaches.

The first part of the Research Memorandum contains a step-by-step checklist of the questions to be asked and factors to be considered in assembling the data required for network systems planning. For example,

*What geographic points are to be connected?

*What is the acceptable time for a user to obtain a service response from the communication line - (For each class of use)?

*Is the required response to be obtained immediately from the system while holding the line open, or by re-establishment of a connection by the central control when an adequate response is generated?

Based upon the above and other considerations, what will be the average "Holding Time" or length of time a given terminal is in uninterrupted communication with a central facility (for each class of use). Holding time should be measured in terms of both the number of characters to be transmitted, and the maximum acceptable elapsed time to accomplish the transmission, whether data, facsimile, voice or video. For example, in the case of voice, it may be the average length of a conversation.

*How many persons are to be served totally?

*How many people can usually share a single terminal in an establishment?

*Hence, how many user establishments must be served?

*How many messages, conversations, transmission, pages or video programs will each person typically initiate or recover daily?

*What are the characteristics of each type of message?

*What hours will be the busy hours for these communication services and will the various uses tend to bunch-up into a single one or two hour period daily?

Following this, RM 10 then outlines the general parameters to be specified in advance of design. For example,

- a. The data flow patterns and amount of data flow from each terminal device location.

Hourly distribution of the information flow at each facility served.

The nature of the information to be communicated.

Impact of peak conditions arising during the year on data flow requirements.

- b. Definition of service criteria or communication system response time.

Need for immediate response.

Answer on demand (within 3 minutes).

Within a reasonable time (5 to 30 minutes).

- c. Nature of the dial-up (information routing scheme).

Number of dial operations required to service the traffic.

Required polling scheme or dialing frequency to meet the service criteria.

Nature of the interaction between priority and non-priority messages.

Also included in the Research Memorandum is a summary of the important communication service offerings of the common carriers that are likely to prove of interest to the Biomedical Communications Network. Described are: private line telegraph channels; 4 KC telephone data links; wide area telephone service; 4.8 KC voice modem; dialpak; wideband data service; telpak service; educational television channels; community antenna television; FM sub-channel approach; communication satellite facilities; and, GSA federal telecommunication system usage. Each of these is described in terms of capability, availability and cost. The section concludes with cost evaluation comparison of all offerings based on a dollar measure of throughput rather than the conventional cost per minute measure.

A hypothetical model is presented as an example of how a communications system serving the medical community through the Biomedical Communications Network would be priced. The example is given for didactic purposes and is not meant to provide a recommended approach for the BCN. It does, however, contain the major functional cost elements to be considered and actually computes the cost of a mixed media communications system serving 268,000 private physicians.

A number of worthwhile conclusions emerge from the study:

1. The mixed media communication objectives of the Biomedical Communications Network appear sound and implementable.
2. The mixed character of the Network's anticipated services will increase the cost of implementation substantially as contrasted to a simple inquiry response or video program service.
3. That a single terminal, added to the physician's home or office, and providing the equivalent capability of a dial telephone and a VHF-UHF TV receiver, is practical.
4. That if existing open educational channels (or UHF channels) of the newer TV sets could be employed with CATV service for semi-demand video educational materials, an inherently low implementation cost would be achieved.
5. That noise considerations in the physician's home and office suggest that mechanical printers be avoided in favor of facsimile, photographic, or electrostatic approaches.

6. That medical libraries in the U.S. will be easier to interconnect and serve because the number of nodes (i.e. user establishments) is more than two orders of magnitude smaller than the number of physicians. The use of Western Union's 40.8 KC Dialpak service, for example, could likely find application to medical libraries since it provides for dial-up and pay-by-the-minute channel capacity for either analog or digital signals.

7: That extensive library information, required without urgency, may better travel via the U.S. mails rather than any other way. Even here, however, consideration should be given to special air express arrangements, automatic wrapping and stamping, and other approaches designed to shorten the overall handling cycle.

RM 11
MEDICAL APPLICATIONS OF
REMOTE ELECTRONIC BROWSING

The development of a Biomedical Communications Network implies the ability to utilize telecommunications facilities in order to make remote inquiries to a file. Thus, in support of the specialized information component of the BCN, the University of Pittsburgh let a sub-contract to the Stanford Research Institute to study medical applications made possible through remote electronic browsing. SRI's charge was to identify and develop viable remote browsing techniques and the requirements for an interactive medical information system that would permit the use of such techniques. RM 11 constitutes the final report under the sub-contract and contains a detailed account of research and development work accomplished.

The main emphasis of SRI's effort has been on two capabilities that are potentially of great importance in facilitating user interaction with medical libraries, information systems, and education systems, namely: (1) remote viewing of text, figures, or plate material; and (2) remote interrogation of computer controlled data files with question-answering abilities. In addition to work in these two areas, consideration was also given to more general aspects of remote browsing, and especially to the problem of integrating remote browsing capabilities into a practical medical information communication system.

Shortly after the inception of the sub-contract, SRI was invited to meetings at the EDUCOM facility in Bethesda, and was there briefed by staff of EDUCOM on the plans and objectives of the LHNCBC R&D effort. SRI was requested to make its own efforts consistent with these plans and objectives. Of critical importance from the point of view of the SRI project was the emergence of the Biomedical Communications Network as a central concept in LHNCBC planning. SRI's objective, therefore, has not been to merely study remote browsing techniques in the abstract, but rather to study remote browsing techniques within the context of the Biomedical Communications Network.

A Biomedical Communications Network serves to connect a variety of differing needs to a variety of storage nodes with a variety of informational and educational materials. Time is a fifth dimension in this problem, since the users, needs, nodes, and materials are all in a process of rapid transition.

Also, a Biomedical Communications Network is essentially a multipurpose system, with a large, and changing, variety of functions. One cannot design such a system merely by conglomerating a number of specific function scenarios. There is usually one item in such a system that is most costly and that also has the greatest longevity. This item becomes a central theme of the design, even though it may represent a means to a variety of ends, rather than an end in itself.

A rough analogy can be drawn here with the design of naval ship systems. The ship itself, although only a means to a variety of ends, is the most central and basic element in the design. The functional elements of a wide variety of missions are condensed, for the most part, on to a relatively small number of generic functional subsystems, for example, propulsion, navigation, fire control, and surveillance.

Analysis of biomedical communications leads to the conclusion that the most important generic functional element capabilities of such a system are question answering and remote viewing. These terms are used in a general sense, and do not imply any given specific implementation. A user seeking to fulfill almost any information need will start out by asking questions of the system (and expecting reasonably intelligent answers) and will usually end up (given the capability) remotely viewing text, figures, plates, or other video material, including in some cases ordinary TV.

A very preliminary configuration analysis of a Biomedical Communications Network leads SRI to believe it could be made economically feasible within the next five years. Other preliminary conclusions reached are:

1. That regional centers are likely to be the primary, but not necessarily the exclusive, sources for remote-viewing of materials and data.
2. That for the near future, hospitals are likely to be the primary receiving points although other biomedically oriented institutions will also have BCN terminals.

3. That the most urgently needed additional communications capability of the Biomedical Communications Network is that of dedicated TV broadcast channels (dedicated to the BCN, not to an individual user), and that for the near term, coaxial cables represent preferred mode of transmission, at least for local distribution.

The main result of SRI's remote browsing study was achievement of a practical and effective method for integrating an assumed Biomedical Communications Network with a proposed remote viewing system. Both the network and the remote viewing system are generic in nature and capable of carrying out a wide variety of medical information and education functions.

The development of both the network and the proposed remote viewing system appears to be strongly supported by current technological trends. Beyond that, there is reason to believe that technological trends and competition will lead to rapid reduction in the operating costs of both the network and the remote viewing system in the next five to ten years.

Also, SRI believes that the proposed remote-viewing display console will play a key role in the development of medical information systems with question-answering capabilities, since interactive access is a key element.

In Section 2.1 of RM 11 the elements of a remote browsing system and a remote browsing development program, based on the results of this study, are outlined. The problems of evaluation and demonstration of such capabilities are also discussed. A development program is defined in terms of approximate schedules

and costs for prototype development and feasibility demonstration.

In Section 2.2 of RM 11 the analysis leading up to SRI's present browsing system conclusions are summarized. The summary includes such aspects as: types of users, types of uses, usage rates, typical scenarios, network design implications, network parameters, and possible network configurations and costs.

Remote Viewing

The objective of remote viewing technology is to deliver pictures to a remote user, on demand, in a rapid and economical manner. The intention is to give him a capability as good as he would have (or better) if he were actually at the location where the materials are stored.

It is assumed that remote viewing starts with the desired page or pages known. A complete remote viewing operation involves at least the following suboperations: (a) finding the document; (b) transporting the document; (c) finding the page; (d) scanning the page; (e) transmitting the intelligence to the user; (f) receiving and storing the data; and, (g) displaying the data to the user.

There are at least several, and in some cases hundreds, of alternatives for each of these suboperations. The net result is a very complex matrix of possibilities. Furthermore, there is a considerable amount of interaction between the various elements of

the process. In this context, a study of remote viewing becomes to some extent a search for the best route through a maze of alternatives.

In choosing heuristic guides to searching, heavy emphasis was placed on systems integration of the remote viewing function into the BCN. This led SRI to a preliminary design concept differing somewhat from its original concept.

Some of the main features of the proposed design concept are as follows:

1. The material to be remotely viewed is assumed to exist primarily in the form of microfiche, with a factor of reduction probably greater than 20, in the interest of compact storage and economical handling.
2. Images destined for remote viewing will be transmitted via the preexisting TV broadcast channels of the BCN, with cables likely to play a role in transmission.
3. Actual picture transmission will occur by frame-addressed or line-addressed units of video, so that one channel can respond to several users at once. This concept will also permit the economical (and simultaneous) servicing of a variety of other educational functions via the same TV channel.
4. The remote viewing display will have the capability for full frame storage, and will therefore not have to be refreshed via the remote channel.
5. The display will also have a capability for handling alpha-numeric and simple graphical information, and insofar as possible will be compatible with other functions of the BCN, and other hospital information requirements.
6. The initial display design will be aimed at achieving minimum cost to the user within a hospital or institutional (multi-unit display system) environment.

Further technological advances will be needed to make such displays economical at the doctor's office (widespread use of cable TV may be the required development).

The main result of SRI's remote viewing studies was a design approach that appears to be feasible, economical, and eminently well-suited for integration into the Biomedical Communications Network. This approach provides the least expensive means for delivering pictures electronically that SRI has been able to envision. The design approach also appears to be highly compatible with BCN requirements for remote interactive access to various data banks.

A key concept in this approach is the idea of line or frame-addressed video information, transmitted via a TV broadcast channel to a specific user. The key element in the design is a remote-viewing display console, with full-frame, or multiple-frame, storage capabilities. In regard to the physical storage part of the remote viewing problem, our analysis has led us to a strong emphasis on high-density microfiche as a preferred alternative.

On the basis of these recommendations and assumptions, it appears that the most important next step in the remote viewing area would be the design, development and demonstration of a remote viewing display subsystem, to refine and prove out the design concepts just discussed.

In Section 3.1 of RM 11 the elements and preliminary design parameters of a proposed remote viewing display subsystem are outlined. A prototype development, evaluation, and demonstration

plan is also outlined and discussed, including approximate schedules and costs for the proposed program.

In Section 3.2 of RM 11 the analysis leading up to SRI's present remote viewing conclusions are summarized. This discussion covers all aspects of remote viewing not just the display and transmission concepts. Aspects discussed include: presentation techniques, display techniques, channel requirements, page storage and handling, book or document handling, and the economic factors associated with various alternatives.

Question-Answering

The objective of question-answering technology is to deliver answers to a remote user, on demand, in a rapid and economical manner. The intention is to give him a capability somewhat comparable to what he would have if he were talking to a knowledgeable person at the information source. The question-answering system will possess somewhat limited reasoning abilities but a really extraordinary memory.

Question-answering embraces the use of a number of techniques: (a) theorem-proving in the predicate calculus; (b) language translation and synthesis; (c) interactive accessing techniques; (d) memory organization and search strategies; (e) language formulation for a given application; and (f) data base encoding.

SRI's question-answering effort to date was devoted to improvements in language translation capabilities, improvements in deductive

capabilities, improvements in memory organization, and improvements in system software. Language formulation and interactive access were given less emphasis, and data base encoding did not proceed very far.

A small data base of approximately 300 statements about 25 anti-hypertensive drugs was placed under electronic control and used in question-answering demonstrations. The ability of this system to analyze a limited version of natural English, form non-trivial conclusions, and return answers was amply demonstrated.

The data base was small and therefore did not constitute a complete feasibility demonstration. Several other factors remain to be assessed. Most important of these are:

1. The economic parameters of a large-scale system, including say as many as 60,000 statements about 3000 drugs, in terms of memory requirements and processing times.
2. The language definition and control problems associated with very large scale systems.
3. The possibilities for the practical evolution of an applied question-answering system, starting from present capabilities and moving forward with concurrent developments in the various functional element areas.

Of the above items, 1. and 3. are the most critical. For if it appears that a full-scale system is economically feasible, and if a practical way can be found to start from present state-of-the-art information system capabilities and evolve toward more sophisticated Q-A systems, most of the other problems will be solved along the way.

Some light may be shed on the economics of a large-scale system by investigating the parameters of the Relational Data File recently implemented at RAND. This system uses a predicate calculus representation, and has considerable parallelism with the Q-A approach used by SRI. It now includes 70,000 factual statements, and was designed to have a capability of 200,000 statements. However, this system has much less powerful deductive and language translation capabilities than the SRI system.

In addition, SRI sees the outline of a practical way to modularize the various elements of an advanced information system with question-answering abilities and then to carry forward the development of these various modules concurrently, with acceptable levels of development risk. This concept is discussed in more detail in the text of RM 11.

SRI has also carried forward the development of deductive and language processing capabilities in the direction needed to support the requirements of a drug effects information system. A small data base was constructed, and the formal ability of the system to carry out language analysis and deductions on this base was demonstrated.

This in itself does not establish the utility and feasibility of such a system based on this technology. An important missing ingredient is the economic cost of data basing, storage, search, and processing in a very large question-answering file. However,

a study of the above mentioned Relational Data File may possibly produce crude estimates of these economic factors without actually building a large data base.

Another important question is how one might move in an evolutionary and practical manner from present information system capabilities toward more advanced capabilities implied by question-answering techniques. RM 11 sheds some light on this issue.

In Section 4.1 of RM 11 the elements of an applied question-answering system are outlined and discussed. A strategy for the evolutionary development of such a system is also defined, together with an approximate schedule of development and demonstration.

In Section 4.2 of RM 11 the results of SRI's technology studies and data base definition efforts are also reviewed, and the future direction of work in this area outlined.

OF GENERAL INTEREST TO ALL COMPONENTS

RM 12
INFORMATION IN HEALTH CARE

This report discusses the need for providing not only the educator and researcher but also the physician providing care to patients--the clinician--with information resources. Patient care could thereby be improved. However there are presently no measures of the effectiveness of patient care; and not enough is known about medicine and its practice to produce a set of rigorous postulates on which to base the design of an information system. Further data are needed: thus, an expression of need, a resolution to investigate, and an admonition to direct the solution to a useful purpose do not by themselves constitute a sufficient framework on which to construct a plan for a biomedical communications network.

The service element of medicine faces problems not necessarily shared by the research and educational branches. One is the rising cost of providing health care. Deficit budgeting as well as the arrangement whereby doctors are not usually employees of a hospital, and the multiple billing which results, may contribute to this. Another and graver problem is the serious shortage of staff, in part due to population increases and a greater demand for medical services, in part to greater awareness of service deficiencies in disadvantaged areas, and in part to a drift away from general practice to more attractive specialization, and to teaching and research.

Service has been affected by the great changes in research brought about by the very large investment in health and the proportionate increase in funds allocated to research; also much research is now interdisciplinary in nature and medicine can hope to benefit more and more from findings in other areas. Teaching has also affected service, the continual changes in the curriculum highlighting attempts to make the course more responsive to current needs. Computer and communications techniques are being explored as possible ways of sharing the resources of others without disproportionate expense.

Service functions in medicine seem to face more problems and more needs than the research and educational functions. Hence the clinician may require a wider range of information and materials which the traditional library is not equipped to provide. This is not to say that it is either desirable or practicable for a given library to handle all types of materials. Special collections must be accessible, however, and access to them facilitated by machine bibliographies, citation indexes and various computer-based surrogates. Audiovisuals and other non-print media should broaden the spectrum of available materials.

Four main groups of information are of interest to the clinician: Original, processed, surrogates to the first two, and ephemera. Original information in research or education, characterized by high volume, irregular format, and a high degree of institutional

or personal individuality are useful to the local institution or individual; on the other hand, original information in service, e.g., the patient record, directly influence succeeding service transactions and therefore are of more general importance. Processed information, starting with books and periodicals, include many non-printed and computer tabulations, and items which may be better portrayed by film or slides. Surrogates and ephemera also play a part for the clinician. Classifying materials in this way does not reveal what should be processed through an information system, but it does suggest that further study be given to some anomalies in their use.

Information is handled in different ways. Scientific journals go through a formal review process, and the reader also benefits from the indexing or cataloging which may be carried out by a distributing organization such as a library. In the case of ephemera, the flow is faster, but the reader loses the benefit of both the screening and the indexing process. There is no handling system for Public Health Service contract reports, and usually trade reports or theses are also not handled. These are therefore difficult for the clinician to refer to. The situation in the audiovisual area too is susceptible of much improvement.

Information in combination may be much more effective. The Drug Information Analysis Service at San Francisco is cited as a viable resource to provide clinicians with published and ephemera

and experienced consultation in pharmacy. In particular areas, special information is needed. In research, information on researchers and on-going research projects is required for setting goals and objectives, information on grants for grant management, processed information from similar disciplines to plan interdisciplinary use of skills, directories of special facilities and equipment to avoid expensive duplication, accounting manuals for accounting, and methods and reports of evaluation for audit and evaluative purposes.

In the educational area, there is need for information on public education, on educational methods and equipment (particularly audiovisuals), on curriculum design, on ways of supplementing the resources of remote preceptors, and on resources (such as computer programs) which can be shared by several medical schools.

In the service area, the information needs are in standards and procedures, in new methods of auditing and evaluation, in better ways of handling medical records, in certain legal problem areas, in compendia of programs to alleviate staff shortages, in information on retraining and on continuing education, in specialized information such as poison control, and in directories of special laboratory facilities. Last but not least, health science libraries need to investigate how innovative technology will enable them to give better service.

The report then discusses the organizational background of the

physician. He is essentially a problem-solver, but his experiences, being episodic, do not necessarily accumulate to provide him with a convenient retrievable repository of information for retrospective use. When he requires further information, the clinician, whether in solo or hospital practice, will turn first to his medical colleagues, then to medical specialists; he can also consult nurses and others involved in patient care, such as pharmacists, case workers and visiting nurses. And he will also consult librarians of health libraries and of medical records.

The clinician has two types of information need: The first is anticipated, discipline-oriented, may be unhurried, and relies on processed materials. Exhaustive searches are performed. His other need is for unanticipated information required when confronted with an obscure diagnosis or a patient not responding to therapy. Speedy response is required. Original, ephemera and processed information are all used, and the clinician moves from the patient's record, to his or other library materials, to other case histories, to disease registries, to processed literature on applied and other research. At any time when he feels he has found the answer he requires, he will break off the search.

Patterns of search suggest that medical records sections of hospitals which can supplement their collection of indexed records with core reference material and consolidate these materials can often provide a more acceptable reference point for clinical

personnel than satellite libraries imposed from outside.

The last section of the report lists the materials provided by the Components of the Biomedical Communications Network and suggests ways in which the Components can make particularly effective contributions to the improvement of patient care.

Improvement in bookhandling techniques to speed service, in microfiche to permit traveling libraries, in facsimile transmission to hasten interlibrary loan, in remote viewing to permit remote browsing, and in automatic indexing for staff-limited libraries, will all increase the value of the Library Component.

Increased coverage of materials by the Specialized Information Services Component, together with use of time-sharing computers, and voice answer back systems to permit computer access by telephone, will enhance this Component's effectiveness. The Specialized Education Services Component needs to experiment with computer-aided and programmed instruction, two-way communications to permit remote student instructor dialogues, and other forms of innovative educational methods.

The Audio and Audiovisual component should try out data compaction for cheaper transmission, black TV utilization, tone decoders so that touchtone telephones can enter central audiotape systems, and speech compression to minimize querying.

The Data Processing Component should make full use of new computer technology and advances in automatic typesetting.

Some requirements for a biomedical communications network are listed. It is stressed that these are general requirements, and that they must be further clarified before functional organization of tasks for an operating network can be described.

RM 13
BIBLIOGRAPHY OF BIOMEDICAL
COMPUTER APPLICATIONS

This bibliography, appropriately produced on a Photon 713, is designed to give biomedical scientists a broad overview of the many applications of computers to their fields. The selection of material for inclusion was made very largely from the holdings of the National Library of Medicine and of the National Institutes of Health Library, and this is reflected by the preponderance of medical journals, rather than computer journals, in the citations.

The annotations were prepared to emphasize the computer applications described in each article. The author's own abstract has been only if he also stresses these facets. The purpose of the annotations is to whet the reader's appetite for more information and to induce him to read the full article. The importance of introducing biomedical scientists gently to computers so that they will not be overawed by them in the future is self-evident, and is crucial in the creation of a successful man-machine interface.

The bibliography is divided into three parts. The first lists four previous bibliographies in this field and refers to a fifth. These together cover the years 1946-1966. Some one-quarter to one-third of the references in Biomedical Computer Applications are later than 1966.

The second part includes a selection of books on computers from the NLM and NIH libraries. The compiler stresses that this should not be regarded as a recommended list of textbooks.

The third and largest part of the bibliography consists of some one thousand articles from journals and chapters from monographs, arranged under broad subject headings such as mathematical models, biocontrol systems, and special purpose computers. The material under one of these headings will give the reader a clear idea of the very broad spectrum of uses possible for computers in medicine. Mathematical models, for example, includes such diverse fields as Parkinson's disease, stuttering, blood-glucose concentration, bone-calcium metabolism, enzyme kinetics, identification of micro-organisms, drug distribution for cancer chemotherapy research, and scanning for brain tumors. Medical headings used, such as electrocardiography, monitoring, diagnosis, and screening, reflect the concentration of effort that has taken place in these particular fields.

Of particular interest in the context of the Technical Development Plan are the last two headings, Drug Service and Drug Information Exchange (Specialized Information Services) and Medical Education (Specialized Education Services). Under the drug heading are annotations on projected computerization in poison control centers, on thesaurus development by the AMA Adverse Reactions Section, on the de Haen Drug Index Card Systems' therapeutic and pharmacological classification-a precursor of automated recording systems, on an International Drug Monitoring System, which will use the computer facilities of the United States Food and Drug Administration, and

on the Drug Information Association which cooperatively developed the Adverse Drug Reaction Dictionary being used in the FDA computerized recording and reporting service (Project RAPID).

Among noteworthy topics under Medical Education are the growing concern with developing computer-oriented biomedical scientists and the curricula for this purpose. The panel on Biological, Management, and Social Sciences of the Committee on the Undergraduate Program in Mathematics has a projected undergraduate program designed to equip the student with enough mathematical knowledge to state biological and medical problems in a rigorous fashion. The University of Arkansas School of Medicine includes lectures on computing in the biometry course for medical students; they are taught GOTRAN, a simplified form of FORTRAN. A number of articles are concerned with undergraduate courses in biomedical engineering to produce graduates familiar with the areas of automation, communication, and computer techniques, and with electronic and automatic laboratory processing. Courses in computer-assisted menu planning for dietitians, and in computer concepts and applications in hospitals are also described. Other annotations deal with the role of computers in medical education of the future, and some present applications, such as differential diagnosis of fevers, and of electrocardiographic abnormalities, and other diagnostic problems. There is also an annotation on scientific journals and information services of the future, recommending a system of centers tied together with a

communications network and performing monitoring and control functions.

The bibliography is well conceived for its role in better acquainting the biomedical scientist with the possibilities of computers.

IV. INDEX TO ACCOMPANYING RESEARCH MEMORANDA

LIBRARY SERVICES COMPONENT

RM-169*	Morris C. Leikind Research Associate in the History of Medicine Division of Medical Sciences Museum of Science and Technology Smithsonian Institution Washington, D.C.	SOME REFLECTIONS ON THE HISTORY OF BIOMEDICAL COMMUNICATIONS (December 1968)
RM-269	Brigitte L. Kenney Systems Analyst Rowland Medical Library The University of Mississippi Medical Center Jackson, Mississippi	HEALTH SCIENCE LIBRARIES TODAY (December 1967)
RM-369	Brigitte L. Kenney Systems Analyst Rowland Medical Library The University of Mississippi Medical Center Jackson, Mississippi	SURVEY OF INTERLIBRARY COMMUNICATIONS SYSTEMS (April 1967)
RM-469	Richard H. Orr Director Institute for Advancement of Medical Communication Philadelphia, Pennsylvania	RATIONALE AND NODE SELECTION FOR INITIAL PHASE OF BIOMEDICAL COMMUNICATIONS NETWORK (October 1968)
RM-569	Richard H. Orr Director Institute for Advancement of Medical Communication Philadelphia, Pennsylvania	INITIAL PHASE DEVELOPMENT OF TH LIBRARY COMPONENT OF THE BIOMEDICAL COMMUNICATIONS NETWORK (January 1969)

*We have referred to the various Research Memoranda throughout this summary as RM 1, RM 2, etc. These same Research Memoranda also have the date of publication added in some references, i.e., RM-169. Thus, RM 1 is identical to RM-169.

SPECIALIZED INFORMATION SERVICES COMPONENT

- | | | |
|--------|--|---|
| RM-669 | E. Harvey Estes Jr.
Chairman
Department of Community
Health Services
Duke University
Medical Center
Durham, North Carolina | MEDICAL INFORMATION SYSTEM--
NEED AND CONCEPT
(February 1967) |
| RM-769 | Richard Walleigh
Research Assistant
EDUCOM | CASE STUDY OF A BIOMEDICAL
INFORMATION NETWORK--POISON
CONTROL CENTERS IN THE
UNITED STATES
(August 1967) |

SPECIALIZED EDUCATION SERVICES COMPONENT

- | | | |
|--------|---|--|
| RM-869 | Tadashi A. Mayeda
Research Associate
EDUCOM | GUIDE TO FACILITIES, CAPABILITIES
AND PROGRAMS OF MEDICAL SCHOOLS
IN THE UNITED STATES
(January 1969) |
|--------|---|--|

AUDIO AND AUDIOVISUAL SERVICES COMPONENT

- | | | |
|--------|--|---|
| RM-969 | William Cooper
Director
Office of Educational
Resources
University of Colorado
Medical Center
Denver, Colorado | ROLE OF AUDIO AND AUDIO-VISUAL
MATERIALS IN ENHANCING THE
LEARNING PROCESS OF HEALTH
SCIENCE PERSONNEL
(January 1969) |
|--------|--|---|

DATA PROCESSING AND DATA
TRANSMISSION FACILITIES SUPPORT COMPONENT

- | | | |
|---------|--|---|
| RM-1069 | Donald L. Dittberner
Center for Management
Technology, Inc.
Bethesda, Maryland | COST FACTORS OF A
COMMUNICATION SUBSYSTEM
(June 1967) |
| RM-1169 | Joseph Chadwick
Program Manager
Information Sciences
Engineering
Stanford Research Institute
Menlo Park, California | MEDICAL APPLICATIONS OF REMOTE
ELECTRONIC BROWSING
(January 1969) |

OF GENERAL INTEREST TO ALL COMPONENTS

- | | | |
|---------|--|---|
| RM-1269 | Tadashi A. Mayeda
Research Associate
EDUCOM | INFORMATION IN HEALTH CARE
(January 1969) |
| RM-1369 | Ruth M. Allen
Public Health Service
U.S. Department of Health,
Education, and Welfare
Washington, D.C. | BIBLIOGRAPHY OF BIOMEDICAL
COMPUTER APPLICATIONS
(1968) |